UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS

FURUKAWA ELECTRIC COMPANY OF NORTH AMERICA; OFS FITEL LLC, Plaintiffs, v. ANTARES DEVELOPMENT INTERNATIONAL LLC, Defendant.	Civil Action No.: 05-cv-11665-RGS

DECLARATION OF JOSHUA L. SOLOMON

JOSHUA L. SOLOMON, first being duly sworn, deposes and says:

1. I am an attorney with the law firm of Sullivan & Worcester LLP.

2. Attached as Exhibit A is a true and accurate copy of a docket report for an action captioned Fitel USA Corp. v. Fibercore, Inc., Civ. A. No. 02-02149-CAP (N.D. Ga.) (the "Furukawa Georgia Action"), as printed on September 1, 2005 from the Northern District of Georgia's Case Management/Electronic Case Files System (the "CM/ECF System").

3. Attached as Exhibit B is a true and accurate copy of the Fourth Amended Complaint in the Furukawa Georgia Action, as printed on September 1, 2005 from the CM/ECF System.

4. Attached as Exhibit C is a true and accurate copy of the Answer and Counterclaim in the Furukawa Georgia Action, as printed on September 1, 2005 from the CM/ECF System.

5. Attached as Exhibit D is a true and accurate copy of a Scheduling Order in the Furukawa Georgia Action, as printed on September 1, 2005 from the CM/ECF System.

Signed under the pains and penalties of perjury on this 1st day of September, 2005.

/s/ Joshua L. Solomon
Joshua L. Solomon

8months, SUBMDJ

U.S. District Court
Northern District of Georgia (Atlanta)
CIVIL DOCKET FOR CASE #: 1:02-cv-02149-CAP

Fitel USA Corp., et al v. Fibercore, Inc., et al
Assigned to: Judge Charles A. Pannell
Demand: $0
Cause: 28:1338 Patent Infringement

Date Filed: 08/02/2002
Jury Demand: Both
Nature of Suit: 830 Patent
Jurisdiction: Federal Question

Plaintiff

Fitel USA Corp. represented by **Frank Garrett Smith, III**
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V.

Defendant

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Defendant

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represented by

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TERMINATED: 09/14/2004
LEAD ATTORNEY

Bernard Luke Zidar
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TERMINATED: 09/14/2004

David Scott Kerven
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ATTORNEY TO BE NOTICED

Mitchell G. Weatherly
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ATTORNEY TO BE NOTICED

Counter Claimant

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(See above for address)
TERMINATED: 07/25/2003
LEAD ATTORNEY

Lawrence K. Nodine

(See above for address)
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David Scott Kerven
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Mitchell G. Weatherly
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V.

Counter Defendant

Fitel USA Corp. represented by **Frank Garrett Smith, III**
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ATTORNEY TO BE NOTICED

Harold Stephen Harris, Jr.
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Michael D. McCoy
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V.

Defendant

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Defendant

Brian Chomniak represented by **Bernard Luke Zidar**
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TERMINATED: 09/14/2004

David Scott Kerven
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Mitchell G. Weatherly
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Counter Claimant

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David Scott Kerven
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Mitchell G. Weatherly
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Counter Claimant

Anand Agarwal represented by **David Scott Kerven**
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ATTORNEY TO BE NOTICED

Mitchell G. Weatherly
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Counter Claimant

Brian Chomniak represented by **David Scott Kerven**
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Mitchell G. Weatherly
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Counter Claimant

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TERMINATED: 09/14/2004
LEAD ATTORNEY

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V.

Counter Defendant

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Harold Stephen Harris, Jr.
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Date Filed	#	Docket Text
08/02/2002	1	COMPLAINT filed and summons(es) issued. Consent form to proceed before U.S. magistrate and pretrial instructions given to attorney; jury demand FILING FEE $ 150.00 RECEIPT # 492235 (aet) (Entered: 08/07/2002)
08/09/2002	2	Application for admission of Michael D. McCoy pro hac vice for plaintiff Fitel USA Corp. (to CAP) (als) (Entered: 08/12/2002)
08/12/2002		Proposed stipulation and order extending time to answer [1-1] complaint . (als) (Entered: 08/15/2002)
08/15/2002	3	ORDER by Judge Charles A. Pannell APPROVING [2-1] pro hac vice application of Michael D. McCoy. (cc) (kt) (Entered: 08/15/2002)

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08/23/2002	4	STIPULATION and ORDER by Judge Charles A. Pannell, extending time to answer [1-1] complaint thru 9/24/02 , Answer due 9/24/02 for Fibercore, Inc. (cc) (als) (Entered: 08/26/2002)
09/24/2002	5	MOTION by defendant to dismiss or in the alternative to transfer case to USDC District of MA with brief in support. (bsm) (Entered: 09/27/2002)
09/24/2002	6	Application for admission of Laurence E. Stein pro hac vice for defendant (to CAP) (adg) (Entered: 09/27/2002)
09/24/2002	7	Application for admission of Joseph V. Colaianni pro hac vice for defendant. (to CAP) (adg) (Entered: 09/27/2002)
10/02/2002	8	ENDORSED ORDER by Judge Charles A. Pannell APPROVING [7-1] pro hac vice application of Joseph V. Colaianni (cc) (als) (Entered: 10/03/2002)
10/02/2002	9	ENDORSED ORDER by Judge Charles A. Pannell APPROVING [6-1] pro hac vice application of Laurence E. Stein (cc) (als) (Entered: 10/03/2002)
10/08/2002	13	Application for admission of J. Alexander Hershey pro hac vice for Fibercore, Inc. (to CAP) (als) (Entered: 10/18/2002)
10/11/2002	10	Response by plaintiff in opposition to [5-1] motion to dismiss (als) (Entered: 10/16/2002)
10/11/2002	11	MOTION by plaintiff to file appendix of exhibits to pla's opposition to dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transer of venue under seal with brief in support. (with SEALED exhibits in support) (als) (Entered: 10/16/2002)
10/11/2002	12	MOTION by plaintiff to file appendix of exhibits to pla's opposition to dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue under seal with brief in support. (appendix of exhibits filed UNDER SEAL) (als) (Entered: 10/16/2002)
10/17/2002		SUBMITTED to Judge Charles A. Pannell on [5-1] motion to dismiss, [5-2] motion to transfer case to USDC District of MA (als) (Entered: 10/17/2002)
10/23/2002	14	ENDORSED ORDER by Judge Charles A. Pannell APPROVING [13-1] pro hac vice application for J. Alexander Hershey (cc) (als) (Entered: 10/24/2002)
10/24/2002	15	Joint MOTION to extend time thru 10/25/02 to file plas initial disclosures and thru 11/01/02 to file prel planning report (cdg) (Entered: 10/28/2002)
10/24/2002	16	Certificate of interested persons. (to judge) (cdg) (Entered: 10/28/2002)
10/25/2002	17	Reply brief to [5-1] motion to dismiss, [5-2] motion to transfer case to USDC District of MA by defendant. (cdg) (Entered: 10/28/2002)
10/25/2002	18	ORDER by Judge Charles A. Pannell GRANTING [15-1] joint motion to

		extend time thru 10/25/02 to file plas initial disclosures and thru 11/01/02 to file dfts initial disclosures and thru 11/12/02 to file prel planning report (cc) (cdg) (Entered: 10/28/2002)
10/30/2002	19	MOTION by plaintiff for leave to file surreply to reply memo in support of dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue with brief in support. (als) (Entered: 11/05/2002)
10/30/2002	20	SURREPLY by plaintiff to reply memo in support of [5-1] motion to dismiss (als) (Entered: 11/06/2002)
11/04/2002	21	Response by defendant in opposition to [19-1] motion for leave to file surreply to reply memo in support of dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue (als) (Entered: 11/12/2002)
11/12/2002	22	Joint Preliminary Report and Discovery Schedule. (to judge) (adg) (Entered: 11/14/2002)
11/13/2002	23	Amended Joint Preliminary Report and Discovery Schedule. (to judge) (adg) (Entered: 11/14/2002)
11/14/2002	24	AMENDED COMPLAINT by plaintiff adding Sterlite Optical (als) (Entered: 11/20/2002)
11/15/2002	25	Summons issued for defendant, Sterlite Optical Technologies, Inc. as to Amended complaint (als) (Entered: 11/20/2002)
11/19/2002	26	REPLY by plaintiff to response to [19-1] motion for leave to file surreply to reply memo in support of dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue (fmm) (Entered: 11/25/2002)
11/20/2002		SUBMITTED to Judge Charles A. Pannell on [11-1] motion to file appendix of exhibits to pla's opposition to dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transer of venue under seal, [12-1] motion to file appendix of exhibits to pla's opposition to dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue under seal, [19-1] motion for leave to file surreply to reply memo in support of dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue (file in chambers) (als) (Entered: 11/20/2002)
12/03/2002	27	MOTION by Fibercore, Inc. to dismiss the allegations of Fitel's first Amended Complaint against Sterlite Optical Technologies Inc , and Renewal of motion to dismiss or to transfer case with brief in support. (als) (Entered: 12/05/2002)
12/10/2002	28	Stipulation and order, extending time to file response to [24-1] amended complaint , Answer due 1/7/03 for Sterlite Optical, for Fibercore, Inc. approved by Judge Charles A. Pannell (als) (Entered: 12/11/2002)
12/13/2002	29	ORDER by Judge Charles A. Pannell GRANTING [5-1] motion to

		dismiss with respect to Fibercore. Pla is directed to file a second amended complaint within 30 days, [29-1] order to be submitted on 1/17/03 (cc) (als) (Entered: 12/17/2002)
12/18/2002	30	ORDER by Judge Charles A. Pannell GRANTING [12-1] motion to file appendix of exhibits to pla's opposition to dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue under seal, GRANTING [11-1] motion to file appendix of exhibits to pla's opposition to dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transer of venue under seal, GRANTING [19-1] motion for leave to file surreply to reply memo in support of dft's motion to dismiss for lack of personal jurisdiction and improper venue, or for transfer of venue (cc) (als) (Entered: 12/18/2002)
12/18/2002		Terminated submissions. (als) (Entered: 12/18/2002)
01/08/2003		SUBMITTED to Judge Charles A. Pannell on [27-1] motion to dismiss the allegations of Fitel's first Amended Complaint against Sterlite Optical Technologies Inc, [27-2] motion to dismiss or to transfer case (als) (Entered: 01/08/2003)
01/09/2003	31	SECOND AMENDED COMPLAINT by plaintiff (als) (Entered: 01/15/2003)
01/24/2003	32	ANSWER by Sterlite Optical to complaint [31-1] Discovery ends 10/21/03; jury demand (als) (Entered: 01/27/2003)
02/13/2003	33	AMENDED ANSWER to [32-1] answer by Sterlite Optical (als) (Entered: 02/18/2003)
02/13/2003	33	COUNTERCLAIM by Sterlite Optical against Fitel USA Corp.; jury demand. (included with amended answer) (als) (Entered: 02/18/2003)
02/24/2003	34	Joint MOTION to extend time thru 3/3/03 to file prel planning report w/prop order (to CAP) (fmm) (Entered: 02/27/2003)
03/03/2003	35	Joint Preliminary Report and Discovery Schedule. (to judge) (als) (Entered: 03/06/2003)
03/07/2003	36	ANSWER by Fitel USA Corp. to counterclaim [33-1] . Discovery ends 12/2/03 (als) (Entered: 03/12/2003)
03/10/2003	37	ORDER by Mag Judge Gerrilyn G. Brill GRANTING [34-1] joint motion to extend time thru 3/3/03 to file prel planning report (cc) (als) (Entered: 03/12/2003)
03/12/2003	38	ENDORSED ORDER by Judge Charles A. Pannell APPROVING [35-1] preliminary statement (cc) (als) (Entered: 03/13/2003)
03/14/2003	39	ENDORSED ORDER by Mag Judge Gerrilyn G. Brill GRANTING [34-1] joint motion to extend time thru 3/3/03 to file prel planning report (cc) (als) (Entered: 03/18/2003)
05/23/2003		Terminated submissions. (fmm) (Entered: 05/23/2003)

07/25/2003	40	Certificate of Consent to withdrawal of Counsel, by Christopher Owen Green withdrawing as attorney for Sterlite Optical (als) (Entered: 07/28/2003)
09/05/2003	41	Application for admission of John P. Higgins pro hac vice for Fitel USA Corp.(to CAP) (als) (Entered: 09/10/2003)
09/10/2003		Proposed confidentiality order. (to CAP) (als) (Entered: 09/16/2003)
09/15/2003	42	ENDORSED ORDER by Judge Charles A. Pannell APPROVING [41-1] pro hac vice application for John P. Higgins (cc) (als) (Entered: 09/17/2003)
09/16/2003	43	PROTECTIVE ORDER ENTERED. (als) (Entered: 09/17/2003)
10/03/2003	44	Notice of filing request by plaintiff to permit entry upon land for inspection (als) (Entered: 01/27/2004)
11/05/2003	45	Joint MOTION to extend discovery thru 12/12/03 (to CAP) (als) (Entered: 11/07/2003)
11/12/2003	46	ORDER by Judge Charles A. Pannell GRANTING [45-1] joint motion to extend discovery thru 12/12/03, Discovery ends 12/12/03 (cc) (als) (Entered: 11/13/2003)
11/26/2003	47	Joint MOTION to extend time to file joint statement of identifying agreed claim terms and disputed claim terms (to CAP) (als) (Entered: 12/03/2003)
12/01/2003	48	Notice of filing Joint Statement identifying agreed calim terms, construction for agreed terms and disputed claim terms. (als) (Entered: 12/08/2003)
12/05/2003	49	ORDER by Judge Charles A. Pannell GRANTING [47-1] joint motion to extend time thru 12/1/03 to file joint statement of identifying agreed claim terms and disputed claim terms (cc) (als) (Entered: 12/10/2003)
12/11/2003	50	MOTION by plaintiff for leave to file third amended complaint , join additional parties , and to extend fact discovery thru 9/30/04 with **SEALED MEMORANDUM** in support. (als) (Entered: 12/12/2003)
12/19/2003	51	Joint MOTION to extend time thru 1/20/04 for dft to file a response to pla's [50-1] motion for leave to file third amended complaint and [50-2] motion join additional parties , to extend time thru 1/20/04 for parties to file joint statement identifying agreed claim terms and construction for agreed terms , and to extend time thru 1/20/04 for the parties to file opening Markman Birefs with proposed order. (To CAP) (lme) (Entered: 12/26/2003)
01/20/2004	52	Response by defendant Sterlite Optical to [50-1] motion for leave to file third amended complaint. (vs) (Entered: 01/21/2004)
01/26/2004		SUBMITTED to Judge Charles A. Pannell on [50-1] motion for leave to file third amended complaint, [50-2] motion join additional parties, [50-3] motion to extend fact discovery thru 9/30/04 (file in chambers) (als)

		(Entered: 01/26/2004)
01/27/2004		Telephone Conference with counsel. Pla's counsel is to file an amended complt and dismiss related case no.: 1:03-cv-3786. Parties are to also file an amended scheduling order. (yrm) (Entered: 02/26/2004)
02/26/2004		Proposed Fourth amended complaint . (als) Modified on 03/18/2004 (Entered: 03/04/2004)
02/26/2004	53	FOURTH AMENDED COMPLAINT by plaintiff adding Furukawa Electric, Limited, Anand Agarwal, Brian Chomniak (als) (Entered: 03/19/2004)
03/11/2004	54	ANSWER by Sterlite Optical, Anand Agarwal, Brian Chomniak, Sterlite Optical to complaint [53-1] and COUNTERCLAIM against Furukawa Electric (als) (Entered: 03/19/2004)
03/25/2004	55	ANSWER by Furukawa Electric to counterclaim [54-2] . (fmm) (Entered: 03/30/2004)
05/06/2004	56	Notice by CRD, status conference is set for 2:00p.m. on 5/19/04 before the Honorable Charles A. Pannell, Jr. in courtroom 2307 , parties to file joint prel report and disc schedule by 5/19/04. (cc by CRD) (als) (Entered: 05/11/2004)
05/19/2004	57	STATUS CONFERENCE HELD before Judge Charles A. Pannell, court verbally deemed all pending motions moot. Supplemental Joint preliminary Report filed. (als) (Entered: 05/20/2004)
05/19/2004		VERBAL ORDER by Judge Charles A. Pannell DENYING as MOOT the [51-1] joint motion to extend time thru 1/20/04 for dft to file a response to pla's [50-1] motion for leave to file third amended complaint and [50-2] motion join additional parties, the [51-2] joint motion to extend time thru 1/20/04 for parties to file joint statement identifying agreed claim terms and construction for agreed terms, the [51-3] joint motion to extend time thru 1/20/04 for the parties to file opening Markman Birefs, the [50-1] motion for leave to file third amended complaint, the [50-2] motion join additional parties, the [50-3] motion to extend fact discovery thru 9/30/04 (als) (Entered: 05/20/2004)
05/19/2004	58	SUPPLEMENTAL Joint Preliminary Report and Discovery Schedule. (to judge) (als) (Entered: 05/20/2004)
05/19/2004	59	ENDORSED ORDER by Judge Charles A. Pannell APPROVING [58-1] preliminary statement (cc) (als) (Entered: 05/20/2004)
05/19/2004		Terminated submissions. (als) (Entered: 05/20/2004)
07/07/2004		Steno notes of proceedings held May 19, 2004 before Judge Charles A. Pannell , by Court Reporter Martha J. Frutchey. (als) (Entered: 07/07/2004)
07/16/2004	60	MOTION for Extension of Time for mediation by Furukawa Electric North America, Inc. (Attachments: # 1 Text of Proposed Order)(als)

		(Entered: 07/28/2004)
07/30/2004	61	MOTION to Withdraw Bernard Luke Zidar as Attorneyby Anand Agarwal, Brian Chomniak, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Limited. (Zidar, Bernard) (Entered: 07/30/2004)
07/30/2004	62	NOTICE by Anand Agarwal, Brian Chomniak, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Limited *of Filing of Corrected Certificate of Service* (Zidar, Bernard) (Entered: 07/30/2004)
08/02/2004	63	ORDER granting 60 Motion to extend the deadline for mediation thru 9/24/04. Signed by Judge Charles A. Pannell on 8/2/04. (als) (Entered: 08/09/2004)
08/13/2004	64	RESPONSE by Furukawa Electric North America, Inc. to 61 dfts' Certificate of Consent to Withdraw Bernard Luke Zidar as Attorney. (Attachments: # 1 Exhibit 1# 2 Exhibit 2)(scg) (Entered: 08/17/2004)
08/19/2004		Submission of 61 MOTION to Withdraw Bernard Luke Zidar as Attorney, submitted to District Judge Charles A. Pannell. (als) (Entered: 08/19/2004)
09/14/2004	65	ORDER granting Defendants' 61 Motion to Withdraw Bernard L. Zidar, Sumner C. Rosenberg and Lawrence K. Nodine as counsel. The defendants are DIRECTED to notify the clerk of the appointment of another attorney w/in twenty (20) days of the docketing of this order. Signed by Judge Charles A. Pannell on 09/14/04. (dfb) (Entered: 09/15/2004)
09/29/2004	66	NOTICE of Appearance by Mitchell G. Weatherly on behalf of Anand Agarwal, Brian Chomniak, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Limited (Weatherly, Mitchell) (Entered: 09/29/2004)
11/08/2004	67	NOTICE of Appearance by David Scott Kerven on behalf of Anand Agarwal, Brian Chomniak, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Limited (Kerven, David) (Entered: 11/08/2004)
01/13/2005	68	MOTION for Discovery by Furukawa Electric North America, Inc.. (Attachments: # 1)(Pulliam, Matthew) (Entered: 01/13/2005)
01/13/2005	69	MOTION for Protective Order by Furukawa Electric North America, Inc.. (Attachments: # 1 # 2 # 3)(Pulliam, Matthew) (Entered: 01/13/2005)
01/13/2005	70	MOTION to Compel Discovery Responses by Furukawa Electric North America, Inc.. (Attachments: # 1)(Pulliam, Matthew) (Entered: 01/13/2005)
01/13/2005	71	MOTION for Extension of Time Extend Fact Discovery Deadline and for a Scheduling Conference by Furukawa Electric North America, Inc.. (Attachments: # 1 # 2 # 3 # 4 # 5 # 6 # 7 # 8 # 9)(Pulliam, Matthew) (Entered: 01/13/2005)
01/13/2005	72	PROPOSED ORDER Proposed Order on Plaintiff's Motion to Compel

		Discovery Responses re: 70 MOTION to Compel Discovery Responses. (Pulliam, Matthew) (Entered: 01/13/2005)
01/18/2005	73	NOTICE Of Filing by Furukawa Electric North America, Inc. *Certificate of Service for Plaintiff's Responses and Objections to Second Request for Admissions of Defendants* (Pulliam, Matthew) (Entered: 01/18/2005)
01/31/2005	74	NOTICE Of Filing Certificate of Service for Defendants' Discovery Served December 16, 2004 by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak, Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak (Attachments: # 1 Supplement COS for Request for Entry Upon Land# 2 Supplement COS Sterlite Second Interrogatories# 3 Supplement COS Sterlite Requests for Admission# 4 Supplement COS Sterlite's Second Requests for Production)(Weatherly, Mitchell) (Entered: 01/31/2005)
02/01/2005	75	RESPONSE in Opposition re 68 MOTION for Discovery, 69 MOTION for Protective Order, 70 MOTION to Compel Discovery Responses, 71 MOTION for Extension of Time Extend Fact Discovery Deadline and for a Scheduling Conference *and Cross Motion* filed by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak. (Attachments: # 1 Text of Proposed Order) (Weatherly, Mitchell) (Entered: 02/01/2005)
02/01/2005	76	AFFIDAVIT *of Mitchell G. Weatherly in Support of Opposition and Cross Motion* by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak. (Weatherly, Mitchell) (Entered: 02/01/2005)
02/02/2005	77	NOTICE by Furukawa Electric North America, Inc. *Certificate of Service of Plaintiff's Initial Identification of Trade Secrets That Were Misappropriated by Defendants* (Pulliam, Matthew) (Entered: 02/02/2005)
02/07/2005	78	NOTICE Of Filing Certificate of Service for Responses to Furukawa's Requests for Production by Anand Agarwal (Kerven, David) (Entered: 02/07/2005)
02/07/2005	79	NOTICE Of Filing Certificate of Service of Responses to Furukawa's Interrogatories by Anand Agarwal (Kerven, David) (Entered: 02/07/2005)
02/07/2005	80	NOTICE Of Filing Certificate of Service of Responses to Furukawa's Requests for Production by Brian Chomniak (Kerven, David) (Entered: 02/07/2005)
02/07/2005	81	NOTICE Of Filing Certificate of Service of Responses to Furukawa's Interrogatories by Brian Chomniak (Kerven, David) (Entered: 02/07/2005)
02/07/2005	82	NOTICE Of Filing Certificate of Service of Verification of Responses to

		Furukawa's Interrogatories by Brian Chomniak (Kerven, David) (Entered: 02/07/2005)
02/07/2005	83	NOTICE Of Filing Certificate of Service for Responses to Furukawa's 3rd Requests for Production by Sterlite Optical Technologies, Inc. (Kerven, David) (Entered: 02/07/2005)
02/07/2005	84	NOTICE Of Filing Certificate of Service for Responses to Furukawa's 3rd Interrogatories by Sterlite Optical Technologies, Inc. (Kerven, David) (Entered: 02/07/2005)
02/07/2005	85	NOTICE Of Filing Certificate of Service for Verification of Resposes to Furukawa's 3rd Interrogatories by Sterlite Optical Technologies, Inc. (Kerven, David) (Entered: 02/07/2005)
02/07/2005	86	NOTICE Of Filing Certificate of Service of Responses to Furukawa's Requests for Production by Sterlite Optical Technologies, Limited (Kerven, David) (Entered: 02/07/2005)
02/07/2005	87	NOTICE Of Filing Certificate of Service for Responses to Furukawa's Interrogatories by Sterlite Optical Technologies, Limited (Kerven, David) (Entered: 02/07/2005)
02/07/2005	88	NOTICE Of Filing Certificate of Service for Verification of Responses to Furukawa's Interrogatories by Sterlite Optical Technologies, Limited (Kerven, David) (Entered: 02/07/2005)
02/08/2005	89	NOTICE Of Filing Certificate of Service for Verification of Responses to Furukawa's Interrogatories by Anand Agarwal (Kerven, David) (Entered: 02/08/2005)
02/08/2005		Submission of 68 MOTION for Discovery, 69 MOTION for Protective Order, 70 MOTION to Compel Discovery Responses, 71 MOTION for Extension of Time Extend Fact Discovery Deadline and for a Scheduling Conference, submitted to District Judge Charles A. Pannell. (als) (Entered: 02/08/2005)
02/16/2005	90	NOTICE of Change of Address for David Scott Kerven, counsel for Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak, Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak (Kerven, David) (Entered: 02/16/2005)
02/17/2005	91	REPLY BRIEF re 68 MOTION for Discovery, 69 MOTION for Protective Order, 70 MOTION to Compel Discovery Responses, 71 MOTION for Extension of Time Extend Fact Discovery Deadline and for a Scheduling Conference *Combined* filed by Furukawa Electric North America, Inc.. (Pulliam, Matthew) (Entered: 02/17/2005)
02/17/2005	92	AFFIDAVIT in Support re 68 MOTION for Discovery, 69 MOTION for Protective Order, 70 MOTION to Compel Discovery Responses, 71 MOTION for Extension of Time Extend Fact Discovery Deadline and for a Scheduling Conference *in support of Combined Reply* filed by

		Furukawa Electric North America, Inc.. (Attachments: # 1 # 2 # 3 # 4 # 5 # 6)(Pulliam, Matthew) (Entered: 02/17/2005)
03/25/2005	93	ORDER directing parties to appear for a Case Status Conference on 4/7/2005 at 09:30 AM before Judge Charles A. Pannell regarding 68, 69, 70, and 71 discovery motions. At least one day prior to hearing, no later than 4/6/05, parties are DIRECTED to provide the court with an amended Joint Preliminary Report and Discovery Plan. (see order for specifics) Signed by Judge Charles A. Pannell on 3/25/05. (als) (Entered: 03/29/2005)
04/11/2005	94	NOTICE of Hearing: Status Conference re-set for 4/19/2005 10:00 AM in Courtroom 2307 before Judge Charles A. Pannell. (yrm) (Entered: 04/11/2005)
04/11/2005	95	NOTICE of Hearing: Status Conference re-set for 4/18/2005 10:00 AM in Courtroom 2307 before Judge Charles A. Pannell. (yrm) (Entered: 04/11/2005)
04/15/2005	96	PRELIMINARY REPORT AND DISCOVERY SCHEDULE filed by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak, Sterlite Optical Technologies, Limited, Furukawa Electric North America, Inc., Fitel USA Corp., Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Inc., Fitel USA Corp., Furukawa Electric North America, Inc., Anand Agarwal, Brian Chomniak. (Kerven, David) (Entered: 04/15/2005)
04/18/2005	97	Minute Entry for proceedings held before Judge Charles A. Pannell : Status Conference held on 4/18/2005. Court heard from counsel, written order to follow. (Court Reporter Martha Frutchey.)(als) (Entered: 04/21/2005)
04/19/2005	98	ORDER granting plaintiff's leave to file 53 Amended Complaint and accepts the Fourth Amended Complaint as filed, dismissing 70 Motion to Compel discovery responses, dismissing as moot 68 Motion for extenstion of time to respond to Discovery, dismissing as moot 69 Motion for Protective Order, granting in part and denying in part 71 Motion for Extension of discovery deadlines and for a scheduling order; motion is dismissed as moot to the extent that the plaintiff moved to extend the discovery deadline until 6/1/05 and discovery will be goverened by the schedule attached as Exhibit A to this order; and Court ADOPTS 96 proposed amended joint preliminary report and discovery plan subject to changes previously set forth in this order. Signed by Judge Charles A. Pannell on 4/19/05. (als) (Entered: 04/22/2005)
05/09/2005	99	Initial Disclosures by Sterlite Optical Technologies, Limited, Anand Agarwal, Anand Agarwal.(Broyles, Keith) (Entered: 05/09/2005)
05/13/2005	100	RESPONSE re 99 Initial Disclosures *of Furukawa's Infringement Contentions* filed by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Inc.. (Attachments: # 1 Exhibit Exhibits 1-2 to Disclosure of Infringement Contentions# 2 Exhibit Exhibits 3-8 to

		Disclosure of Infringement Contentions)(Weatherly, Mitchell) (Entered: 05/13/2005)
05/18/2005	101	RESPONSE re 99 Initial Disclosures, 100 Response (Non-Motion), Response (Non-Motion) filed by Furukawa Electric North America, Inc.. (Broyles, Keith) (Entered: 05/18/2005)
06/01/2005	104	ORDER Denying any relief sought by Sterlite in its 100 Response (Non-Motion) to Plaintiff's Disclosure of Infringement Contentions. The court EXTENDS: (1) the June 1, 2005, deadline for Sterlite to serve their response to Furukawa's Disclosure of Infringement Contentions and to disclose their invalidity contentions until June 7, 2005; (2) the June 7, 2005, deadline for Furukawa to file any objections to the sufficiency of Sterlite's disclosures until June 13, 2005; (3) the June 13, 2005, deadline for Sterlite to respond to any objections filed by Furukawa until June 20, 2005. No other deadline shall be extended as a result of these changes. Signed by Judge Charles A. Pannell on 6/1/05. (als) Modified on 6/6/2005 to correct docket text (als). (Entered: 06/06/2005)
06/03/2005	102	CERTIFICATE OF SERVICE by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak *for Defendants' Responses to Plaintiff's Disclosure of Infringement Contentions Pursuant to Patent L.R. 4.2* (Kerven, David) (Entered: 06/03/2005)
06/03/2005	103	CERTIFICATE OF SERVICE by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak *Defendants' Disclosure of Invalidity Contentions Pursuant to Patent L.R. 4.3* (Kerven, David) (Entered: 06/03/2005)
06/07/2005	105	RESPONSE re 100 Response (Non-Motion), Response (Non-Motion) *Furukawa's Objections to Defendants' Disclosure of Invalidity Contentions* filed by Furukawa Electric North America, Inc.. (Attachments: # 1 # 2)(Broyles, Keith) (Entered: 06/07/2005)
06/14/2005	106	CERTIFICATE OF SERVICE by Furukawa Electric North America, Inc. *Notice of Claim Terms* (Broyles, Keith) (Entered: 06/14/2005)
06/16/2005	107	NOTICE by Furukawa Electric North America, Inc. *Notice of Withdrawal of Counsel* (Broyles, Keith) (Entered: 06/16/2005)
06/17/2005	110	APPLICATION for Admission of Bruce J. Rose Pro Hac Vice by Fitel USA Corp., Furukawa Electric North America, Inc.Filing Fee received $150.00, Receipt #538462. (als) (Entered: 06/28/2005)
06/21/2005	108	RESPONSE re 105 Response (Non-Motion) *to Plaintiff's Objections to Defendants' Disclosure of Invalidity Contentions* filed by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc.. (Weatherly, Mitchell) (Entered: 06/21/2005)
06/21/2005	109	CERTIFICATE OF SERVICE by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc. *re Defendants' Proposed List of Claim Terms, Phrases and Clauses for Interpretation* (Weatherly, Mitchell)

		(Entered: 06/21/2005)
06/21/2005		Remark: Application for Admission Pro Hac Vice for Bruce J. Rose received 6/17/05. The application is currently incomplete and is being held in the Admin Office pending completion. (jeh) (Entered: 06/21/2005)
06/28/2005	111	ORDER approving 110 Application for Admission Pro Hac Vice of Bruce J. Rose. Signed by Judge Charles A. Pannell on 6/28/05. (als) (Entered: 07/01/2005)
07/01/2005	112	Joint MOTION for Extension of Time Joint Motion and Stipulation to Extend Date to Exchange Preliminary Proposed Claim Construction by Furukawa Electric North America, Inc.. (Broyles, Keith) (Entered: 07/01/2005)
07/01/2005	113	ORDER stating Court finds that Sterlite's Disclosure of InvalidityContentions does not fully comply with Patent Local Rule 4.3. and directing Sterlite to serve the plaintiff with its Supplemental Disclosure of Invalidity Contentions no later than July 15, 2005. The Supplemental Disclosure ofInvalidity Contentions must fully comply with all aspects ofLocal Patent Rule 4.3. No other deadlines in the case will beaffected by this change. Signed by Judge Charles A. Pannell on 7/1/05. (als) (Entered: 07/06/2005)
07/06/2005	114	ORDER granting 112 Joint Motion for Extension of Time for parties to exchange a preliminary proposed construction of each claim term, phrase or clause, which any party has identified for claim construction thru 7/11/05. Signed by Judge Charles A. Pannell on 7/6/05. (als) Modified on 7/12/2005 to correct text. (als). (Entered: 07/08/2005)
07/12/2005	115	CERTIFICATE OF SERVICE by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Inc. *for Defendants' Proposed Interpretation of Claim Terms, Phrases and Clauses* (Kerven, David) (Entered: 07/12/2005)
07/12/2005		Notification of Docket Correction re 114 Order on Motion for Extension of Time, Modified to correct docket text to reflect deadline of 7/11/05. First paragraph of order states 7/11/05 deadline and last paragraph states 7/1/05 deadline. The correct deadline is 7/11/05. (als) (Entered: 07/12/2005)
07/21/2005	116	Joint MOTION for Extension of Time to File Joint Claim Construction Statement with Brief In Support by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Furukawa Electric North America, Inc., Anand Agarwal, Brian Chomniak. (Weatherly, Mitchell) (Entered: 07/21/2005)
07/26/2005	117	ORDER granting 116 Motion for Extension of Time to file joint claim construction statement until 7/29/05. Signed by Judge Charles A. Pannell on 7/26/05. (als) (Entered: 07/27/2005)

07/29/2005	118	Joint Claim Construction Statement filed by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Furukawa Electric North America, Inc., Anand Agarwal, Brian Chomniak.. (Weatherly, Mitchell) (Entered: 07/29/2005)
08/12/2005	119	MOTION for Leave to File Excess Pages *For Plaintiff's Markman Brief on Proper Claim Construction* with Brief In Support by Furukawa Electric North America, Inc., Furukawa Electric North America, Inc.. (Attachments: # 1 Text of Proposed Order Granting Leave to File Excess Pages)(Broyles, Keith) (Entered: 08/12/2005)
08/12/2005	120	Markman Brief *on Proper Claim Construction* filed by Furukawa Electric North America, Inc., Furukawa Electric North America, Inc... (Broyles, Keith) (Entered: 08/12/2005)
08/12/2005	121	NOTICE by Furukawa Electric North America, Inc., Furukawa Electric North America, Inc. re 120 Markman Brief *Appendix with Attached Exhibits* (Attachments: # 1 Exhibit 1. United States Patent No. 4,909,816# 2 Exhibit 2. United States Patent No. 5,298,047# 3 Exhibit 3. United States Patent No. 5,418,881# 4 Errata 4. Excerpts from "Understanding Fiber Optics", by Jeff Hecht# 5 Exhibit 5. Excerpts from Deposition Transcript, John B. Mac Chesney; June 14, 2005# 6 Exhibit 6. Application No. 06/517,430# 7 Exhibit 7. Preliminary Amendment; July 26, 1983# 8 Exhibit 8. Application No. 07/924,278# 9 Exhibit 9. Office Action, July 1, 1993# 10 Exhibit 10. Amendment; September 10, 1993# 11 Exhibit 11. Proposed Amendment, September 20, 1993# 12 Exhibit 12. Preliminary Amendment, December 9, 1993# 13 Exhibit 13. Office Action, July 6, 1994# 14 Exhibit 14. Amendment, June 3, 1994# 15 Exhibit 15. Office Action, July 6, 1994# 16 Exhibit 16. Preliminary Amendment, October 3, 1994# 17 Exhibit 17. Edward H. Phillips v. AWH Corporation, Hopeman Brothers, Inc. and Lofton Corporation, 75 U.S.P.Q. 2d (BNA) 1321.# 18 Exhibit 18. Response, November 12, 1976# 19 Exhibit 19. Amendment, May 14, 1979# 20 Exhibit 20. Edwards Systems Tech., Inc. v. Digital Control Systems, Inc., 99 Fed. Appx. 911.# 21 Exhibit 21. Response to Office Action, September 5, 1975# 22 Exhibit 22. Preliminary Amendment, August 26, 1977# 23 Exhibit 23. Application Serial No. 06/147,934# 24 Exhibit 24. Application Serial No. 06/382,401# 25 Exhibit 25. Request for Reconsideration, August 6, 1984# 26 Exhibit 26. Affidavit, April 23, 1976# 27 Exhibit 27. Application Serial No. 06/828,617# 28 Exhibit 28. United States Patent No. 4,308,045# 29 Exhibit 29. United States Patent No. 4,427,717# 30 Exhibit 30. United States Patent No. 4,028,081) (Broyles, Keith) (Entered: 08/12/2005)
08/12/2005	122	Markman Brief *for Proper Claim Construction* filed by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Inc... (Weatherly, Mitchell) (Entered: 08/13/2005)
08/12/2005	124	NOTICE Of Filing sealed material by Sterlite Optical Technologies, Limited, Sterlite Optical Technologies, Inc., Anand Agarwal, Brian

		Chomniak DOCUMENT FILED UNDER SEAL (als) (Entered: 08/15/2005)
08/13/2005	123	Markman Brief *on U.S. Patent No. 4,909,816* filed by Sterlite Optical Technologies, Limited, Fibercore, Inc., Sterlite Optical Technologies, Inc., Anand Agarwal, Brian Chomniak.. (Weatherly, Mitchell) (Entered: 08/13/2005)
09/01/2005		Submission of 119 MOTION for Leave to File Excess Pages *For Plaintiff's Markman Brief on Proper Claim Construction*, submitted to District Judge Charles A. Pannell. (dcs) (Entered: 09/01/2005)

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IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF GEORGIA
ATLANTA DIVISION

FILED IN CLERK'S OFFICE
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FEB 26 2004

LUTHER D. THOMAS, Clerk
By: Deputy Clerk

FURUKAWA ELECTRIC NORTH AMERICA, INC.

Plaintiff,

v.

STERLITE OPTICAL TECHNOLOGIES, INC.; STERLITE OPTICAL TECHNOLOGIES, LIMITED; ANAND AGARWAL; and BRIAN CHOMNIAK,

Defendants.

Civil Action No.
1: 02 - CV - 2149 CAP

FOURTH AMENDED COMPLAINT

Plaintiff Furukawa Electric North America, Inc. ("Furukawa") files its Fourth Amended Complaint with the consent of defendant Sterlite Optical Technologies, Inc. and with leave of the Court pursuant to Rule 15(a) and alleges as follows:

The Parties

1. Furukawa is a Delaware corporation having its principal place of business at 2000 Northeast Expressway, Norcross, Georgia 30071. Furukawa designs, manufactures, and supplies leading edge optical fiber, optical fiber

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cable, optical connectivity products and specialty photonics products for high speed optical networks. On December 18, 2003 Fitel USA Corp., previously named plaintiff in this action, changed its name to Furukawa Electric North America, Inc.

2. Sterlite Optical Technologies Inc. ("Sterlite U.S.") is a Georgia corporation with United States headquarters and a fiber optic cable division manufacturing facility located at 4386 Park Drive, Norcross, Georgia, 30093. Sterlite U.S. imports into the United States optical fiber made in India, packages the optical fiber into optical fiber cable in Georgia and sells the optical fiber and optical fiber cable in this judicial district and elsewhere. Sterlite U.S. may be served through its registered agent Scott K. Harris, Three Ravinia Drive, Suite 1450, Atlanta, Georgia 30346.

3. Defendant Sterlite Optical Technologies, Limited ("Sterlite India") is a company organized under the laws of India having its registered office at E-1, Waluj M.I.O.C. Industrial Area, Waluj, District Aurangabad 431136, Maharashita, India.

4. Upon information and belief, Sterlite India completely controls and dominates Sterlite U.S. Upon information and belief, Sterlite U.S. is merely an agent, alter ego or business conduit of Sterlite India.

5. Upon information and belief, Sterlite U.S. is grossly undercapitalized, has failed to observe corporate formalities and has non-functioning directors.

6. Upon information and belief, as of November 3, 2003, Sterlite India directly or through Sterlite U.S. operated a website that stated in part: "Sterlite Optical Technologies is one of the leading developers and manufacturers of Optical Fiber and Fiber Optic cables worldwide. Headquartered in Atlanta, Georgia, USA, we have state-of-the-art manufacturing facilities located across the world." Accordingly, Sterlite India holds itself out as having its headquarters in Atlanta, Georgia. Sterlite India imports, sells, offers for sale and uses in Norcross, Georgia, directly or through Sterlite U.S., optical fiber, which is the subject of this lawsuit.

7. Upon information and belief, Anand Agarwal is a citizen of India who is currently a resident of Duluth County, Georgia at 2620 North Berkeley Lake Road N.W. Anand Agarwal is an officer of Sterlite India and Sterlite U.S.

8. Brian Chomniak is a U.S. citizen and a resident of Duluth , Georgia, at 8730 Innisbrook Run and an officer of Sterlite U.S.

Jurisdiction And Venue

9. This is an action for patent infringement arising under the U.S. Patent Laws, Title 35 U.S.C. § 1 *et seq.* and trade secret misappropriation arising under O.C.G.A. § 10-1-760 *et seq.* This Court has jurisdiction over this action under 28 U.S.C. § 1338(a) and supplemental jurisdiction under 28 U.S.C. §1367. Defendant Sterlite India is subject to personal jurisdiction in this district because it imports, sells, offers for sale and uses in Norcross, Georgia, directly or through its agent, alter ego or business conduit, Sterlite U.S., optical fiber using patents and trade secrets that are the subject of this lawsuit. Sterlite U.S. is located in Norcross, Georgia. Sterlite India also holds itself out to the public that it is headquartered in Atlanta, Georgia. Venue is proper in this Court pursuant to 28 U.S.C. §§ 1391 and 1400.

The Patents-in-Suit

10. On March 20, 1990, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 4,909,816 ("the '816 patent"), entitled "Optical Fiber Fabrication And Resulting Product." A copy of the '816 patent is attached hereto as Exhibit A.

11. On March 29, 1994, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 5,298,047 (the '047 patent"), entitled

"Method of Making A Fiber Having Low Polarization Mode Dispersion Due to A Permanent Spin." A copy of the '047 patent is attached hereto as Exhibit B.

12. On May 23, 1995, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 5,418,881 (the '881 patent"), entitled "Article Comprising Optical Fiber Having Low Polarization Mode Dispersion, Due to Permanent Spin." A copy of the '881 patent is attached hereto as Exhibit C.

13. Furukawa, through assignments, is the owner of the entire right, title and interest in and to the '816, '047 and '881 patents (collectively the "Furukawa patents").

14. The '816 patent relates generally to a method of making an optical fiber preform suitable for drawing into an optical fiber. The '816 patent discloses a method of making such a preform through a chemical reaction within a glass tube. The reaction may occur within a constantly traversing hot zone, and the tube may be rotated during processing.

15. The '047 and '881 patents are directed generally to single mode optical fibers. The presence of birefringence in such fiber can limit the usefulness of the fiber due to signal dispersion, known as polarization mode dispersion (PMD). The '047 patent relates to a method of making an optical fiber having low

PMD due to a spin impressed on the fiber. The '881 patent relates to an optical fiber having a spin impressed thereon and an optical communication system including such a fiber.

16. The method of making an optical fiber preform disclosed in the '816 patent and the method of making a fiber having an impressed spin, the spin impressed fiber itself, and articles that comprise such fiber (e.g., an optical fiber communication system) disclosed in the '047 and '881 patents were all pioneered by Furukawa and its predecessor in interest, AT&T Corp., through extensive investments of time and money in research and development. The inventiveness represented by these scientific advances was recognized by the United States Patent Office through the grants of the '816, '047 and '881 patents. Furukawa has also made and continues to make extensive expenditures of time and money for advertising, marketing and additional technical developments relating to these inventions.

17. Upon information and belief, Sterlite U.S. has imported, offered for sale, sold, and used within the United States, optical fiber made in accordance with one or more claims of the '816 patent, and imported, offered for sale, sold, and used optical fiber having an impressed spin and fiber optic cable incorporating optical fiber having an impressed spin, both being covered by one

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or more claims of the '047 and '881 patents, and is continuing to do so. Upon information and belief, Sterlite India, directly or through its agent, alter ego, or business conduit, Sterlite U.S., has imported, offered for sale, sold, and used within the United States, optical fiber made in accordance with one or more claims of the '816 patent, and imported, offered for sale, sold, and used optical fiber having an impressed spin and fiber optic cable incorporating optical fiber having an impressed spin, both being covered by one or more claims of the '047 and '881 patents, and is continuing to do so.

18. Upon information and belief, the optical fiber and fiber optic cables having an impressed spin manufactured, offered for sale and sold by Sterlite U.S. and Sterlite India have been used in the United States by their customers in articles such as optical communication systems. These articles used by Sterlite U.S.' and Sterlite India's customers are covered by one or more claims of the '881 patent.

Count 1 – Direct Infringement Of The '816 Patent

19. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

20. Upon information and belief, Sterlite U.S. has directly infringed and is directly infringing the '816 patent by importing, offering to sell, selling and

using in the United States optical fiber made by a method covered by one of more claims of the '816 patent.

21. Upon information and belief, Defendant Sterlite India has directly infringed and is directly infringing the '816 patent by importing, offering to sell, selling and using within the United States, directly, or through its agent, alter ego, or business conduit, Sterlite U.S., optical fiber made by a method covered by one of more claims of the '816 patent.

22. As a consequence of Sterlite U.S.' and Sterlite India's infringement of the '816 patent, Furukawa has been and continues to be damaged.

23. Unless enjoined, Sterlite U.S. and Sterlite India will continue their infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 2 - Direct Infringement Of The '047 Patent

24. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

25. Upon information and belief, Sterlite U.S. has directly infringed and is directly infringing the '047 patent by importing, offering to sell, selling and using in the United States optical fiber made by a method covered by one or more claims of the '047 patent.

26. Upon information and belief, Defendant Sterlite India has directly infringed and is directly infringing the '047 patent by importing, offering to sell, selling and using within the United States, directly, or through its agent, alter ego, or business conduit, Sterlite U.S., optical fiber made by a method covered by one of more claims of the '047 patent.

27. As a consequence of Sterlite U.S.' and Sterlite India's infringement of the '047 patent, Furukawa has been and continues to be damaged.

28. Unless enjoined, Sterlite U.S. and Sterlite India will continue their infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 3 – Direct Infringement Of The '881 Patent

29. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

30. Upon information and belief, Sterlite U.S. has directly infringed and is directly infringing the '881 patent by offering for sale and selling optical fiber having a spin impressed on the fiber, which is covered by one or more claims of the '881 patent.

31. Upon information and belief, Defendant Sterlite India has directly infringed and is directly infringing the '816 patent by importing, offering to sell,

selling and using within the United States, directly, or through its agent, alter ego, or business conduit, Sterlite U.S., optical fiber made by a method covered by one of more claims of the '816 patent.

32. As a consequence of Sterlite U.S.' and Sterlite India's infringement of the '881 patent, Furukawa has been and continues to be damaged.

33. Unless enjoined, Sterlite U.S. and Sterlite India will continue their infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 4 - Inducing Infringement Of The '881 Patent

34. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

35. Upon information and belief, Sterlite U.S. has actively induced and are actively inducing infringement of the '881 patent by teaching, encouraging and inducing its customers to incorporate optical fiber having an impressed spin, into infringing systems in the United States.

36. As a consequence of Sterlite U.S.' inducement of infringement, Furukawa has been and continues to be damaged.

37. Unless enjoined, Sterlite U.S. will continue their infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 5 - Contributory Infringement Of The '881 Patent

38. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

39. Upon information and belief, Sterlite U.S. and Sterlite India have contributed to the direct infringement of the '881 patent by their customers by selling its customers optical fiber having an impressed spin. Upon information and belief, Sterlite U.S.' customers are using the optical fiber sold to them by Sterlite India, through its agent, alter ego, and business conduit, Sterlite U.S. in systems covered by one or more claims of the '881 patent and such fiber has no substantial non-infringing use.

40. As a consequence of Sterlite U.S.' and Sterlite India's contributory infringement of the '881 patent, Furukawa has been and continues to be damaged.

41. Unless enjoined, Sterlite U.S. and Sterlite India will continue their infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 6 - Inducing Infringement Of The '816 Patent (Alternative)

42. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

43. Upon information and belief, Defendant Sterlite India has actively induced and is actively inducing infringement of the '816 patent by knowingly and intentionally aiding, abetting, and encouraging Sterlite U.S. to import, use, offer for sale and sell within the United States, optical fiber made by a method covered by one of more claims of the '816 patent

44. As a consequence of Sterlite India's inducement of infringement, Furukawa has been and continues to be damaged.

45. Unless enjoined, Sterlite India will continue its infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 7 - Inducing Infringement Of The '047 Patent (Alternative)

46. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

47. Upon information and belief, Defendant Sterlite India has actively induced and is actively inducing infringement of the '047 patent by knowingly

and intentionally aiding, abetting, and encouraging Sterlite U.S. to import, use, offer for sale, and sell in the United States optical fiber made by a method covered by one or more claims of the '047 patent.

48. As a consequence of Sterlite India's inducement of infringement, Furukawa has been and continues to be damaged.

49. Unless enjoined, Sterlite India will continue its infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 8 – Inducing Infringement of the '881 Patent
(Alternative)

50. The allegations of paragraphs 1 through 18 are incorporated herein by reference.

51. Upon information and belief, Defendant Sterlite India has actively induced and is actively inducing infringement of the '881 patent by teaching, encouraging and inducing its customers to incorporate optical fiber having an impressed spin, which is made and sold to them by Sterlite India, into infringing systems in the United States. Upon information and belief, Sterlite India has actively induced and is actively inducing infringement of the '881 patent by aiding, abetting, and encouraging Sterlite U.S. to import, use, offer for sale, and

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sell within the United States optical fiber having an impressed spin, which is made and sold to Sterlite U.S. by Sterlite India.

52. As a consequence of Sterlite India's inducement of infringement, Furukawa has been and continues to be damaged.

53. Unless enjoined, Sterlite India will continue its infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

Count 9 - Willful Infringement

54. The allegations of paragraphs 1 through 53 are incorporated herein by reference.

55. Upon information and belief, at all times during which Sterlite U.S. and Sterlite India have directly or indirectly infringed the '816, '047 and '881 patents, they have been aware of the Furukawa patents and that their activities constitute infringement of the Furukawa patents.

56. Upon information and belief, Sterlite U.S.' and Sterlite India's infringement has been and continues to be deliberate and willful.

57. As a consequence of Sterlite U.S.' and Sterlite India's willful infringement, Furukawa has been and continues to be damaged.

58. Unless enjoined, Sterlite U.S. and Sterlite India will continue their willfully infringing acts, thereby causing Furukawa irreparable injury for which there is no adequate remedy by law.

59. This is an exceptional case under 35 U.S.C. § 285.

Count 10 – Misappropriation of Trade Secrets

60. Paragraphs 1 through 9 are incorporated herein by reference.

61. Plaintiff Furukawa, through its predecessors in interest, AT&T Corp. (referred to herein below as "AT&T Bell Laboratories") and Lucent Technologies, Inc. ("Lucent") was the developer and is now the owner of all right, title and interest in certain confidential, proprietary and trade secret technology relating to the manufacture of optical fiber. Since at least the early 1970's AT&T Bell Laboratories and it successor Lucent have spent substantial sums of money developing fiber optic technology, including processes for making optical fiber, the optical fiber itself, and uses for the optical fiber. Plaintiff Furukawa's success is founded on being able to deliver high quality optical fiber products at a competitive market price, in part, through utilization of this confidential, trade secret technology.

62. Lucent's trade secret technology derives economic value from not being generally known to and not readily ascertainable by proper means by other persons who can obtain economic value from its disclosure or use.

63. The Lucent trade secret technology is the subject of efforts that are reasonable under the circumstances to maintain its secrecy.

64. Upon information and belief, Defendant Sterlite India began producing optical fiber about 1995.

65. In September 1999, representatives from Defendant Sterlite India met with representatives of Lucent, Plaintiff Furukawa's predecessor. At that meeting Defendant Sterlite India requested that Lucent grant Defendant Sterlite India a license to use technology which Lucent owned and had developed along with its predecessor in interest, AT&T Bell Laboratories, to make optical fiber.

66. Defendant Sterlite India wanted Lucent's technology so that Sterlite India could reduce the cost of making optical fiber while improving the quality of the optical fiber and increasing its optical fiber capacity.

67. Lucent Technologies did not grant Defendant Sterlite India a license to use Lucent Technologies' technology for making optical fiber.

68. Upon information and belief, Defendant Sterlite India tried but was unsuccessful in achieving the goals it set to reduce its manufacturing costs,

improve the quality of its optical fiber and increase its optical fiber manufacturing capacity.

69. Between about March and August of 2001, Defendant Sterlite India directed Defendant Sterlite U.S. to hire then-current or past Lucent employees in order to acquire Lucent's optical fiber technology, some of the same technology that Lucent had refused to license to Defendant Sterlite India. Defendant Sterlite U.S. hired at least four Lucent Technology employees who had worked with and were knowledgeable in Lucent's optical fiber technology, including without limitation, Lucent's MCVD and optical fiber drawing technology and Lucent's technology relating to low PMD due to a spin impressed on the fiber.

70. Defendant Sterlite India, directly or indirectly through Sterlite U.S., hired the former Lucent employees to improperly acquire Lucent's optical fiber technology, including trade secrets that Lucent had refused to license to Defendant Sterlite India in 1999. Defendant Sterlite U.S. and its officer, Defendant Chomniak, aided and abetted by Sterlite India, wrongfully acquired from at least one of the former Lucent employees Lucent's trade secret technology. Defendants Chomniak and Sterlite U.S. then provided Lucent's trade secret technology to Sterlite India. Defendants, Sterlite India, Sterlite U.S., and Chomniak, knew or should have known that Lucent's trade secret

technology had been derived from one or more former Lucent employees who owed a duty to Lucent to maintain the secrecy of the information and was acquired by improper means. Defendants Sterlite India, Sterlite U.S., and Chomniak have misappropriated Lucent's trade secret technology for making optical fiber.

71. Upon information and belief, Defendants Sterlite India, Sterlite U.S., and Chomniak have also used and disclosed some of Lucent's trade secret information that was wrongfully acquired from or through Sterlite U.S. and Defendant Chomniak. Sterlite India knew or had reason to know that such use and disclosure was without the consent of Lucent, and that Lucent's trade secrets had been acquired by improper means. As a result, Defendants Sterlite India, Sterlite U.S., and Chomniak have further misappropriated Lucent's trade secret technology for making optical fiber.

72. On or about November 2001, Plaintiff Furukawa obtained all right, title and interest in Lucent's optical fiber business, including all of Lucent's optical fiber technology, which includes patents and trade secrets.

73. Defendants Sterlite India's, Sterlite U.S.', and Chomniak's actions of inducing at least one of the former Lucent employees to disclose Furukawa's trade secret information and Sterlite India's, Sterlite U.S.', and Chomniak's

acquisition and use of at least some of Furukawa's trade secret information constitutes misappropriation of Plaintiff Furukawa's trade secrets in violation of O.C.G.A. § 10-1-760 *et seq*. Upon information and belief, Defendant Agarwal aided and assisted Defendants Sterlite India, Sterlite U.S., and Chomniak with the wrongful disclosure, acquisition and use of Furukawa's trade secret technology.

74. Defendants' acts of misappropriation were willful and malicious and have actually and proximately caused injury to Plaintiff Furukawa by, among other things, depriving Furukawa of sales of optical fiber and the advantages provided by Furukawa's ownership and rights in its trade secret technology. Such damages and losses by Plaintiff Furukawa constitute irreparable harm.

75. Defendants' conduct has caused and, if not enjoined, will continue to cause injury to Plaintiff Furukawa and to its business, for which injury Plaintiff Furukawa is entitled to receive monetary damages and other appropriate relief.

Jury Demand

76. Plaintiff Furukawa demands a trial by jury on all issues triable by jury.

Prayer For Relief

WHEREFORE, Furukawa prays as follows:

A. A judgment that Defendants Sterlite India and Sterlite U.S. have directly infringed or induced infringement of the '816, '047, and '881 patents;

B. An injunction permanently prohibiting Sterlite U.S. and Sterlite India, and their officers, directors, employees, agents and those persons acting in concert therewith, from directly or indirectly infringing the '816, '047 and '881 patents;

C. An award of damages adequate to compensate for the infringement, and that these damages be trebled pursuant to 35 U.S.C. § 284;

D. An award of reasonable attorneys' fees pursuant to 35 U.S.C. §285, interests, and costs;

E. A judgment that Sterlite U.S., Sterlite India, Anand Agarwal, and Brian Chomniak have misappropriated Furukawa's trade secrets relating to the manufacture of optical fiber;

F. A judgment holding that Sterlite U.S. is merely an agent, alter ego, or business conduit of Sterlite India and that Sterlite India is liable to Furukawa for the damages caused by Sterlite U.S.;

G. An injunction permanently prohibiting Anand Agarwal, Brian Chomniak, and Sterlite India and Sterlite U.S., their officers, directors, employees, agents, and those persons acting in concert therewith, from directly or indirectly making any further disclosure of Furukawa's trade secrets;

H. A judgment that Sterlite U.S.', Sterlite India's, Anand Agarwal's, and Brian Chomniak's misappropriation was willful;

I. An award to Furukawa of damages adequate to compensate for the misappropriation, and that the damages be enhanced pursuant to O.C.G.A. § 10-1-763;

J. An award to Furukawa of reasonable attorneys fees, pursuant to O.C.G.A. § 10-1-764, interest, and costs;

K. An accounting of Sterlite U.S.' and Sterlite India's sales and profits for sales of optical fiber, including cable incorporating the optical fiber that was made using Furukawa's trade secret technology; and.

L. Such other and further relief as is just and proper.

Respectfully submitted this 26th day of February, 2004.

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CLT01/4629848v1

EXHIBIT / ATTACHMENT

A

(To be scanned in place of tab)

United States Patent [19]

Hart, Jr. et al.

[11] Patent Number: 5,418,881

[45] Date of Patent: May 23, 1995

[54] ARTICLE COMPRISING OPTICAL FIBER HAVING LOW POLARIZATION MODE DISPERSION, DUE TO PERMANENT SPIN

[75] Inventors: Arthur C. Hart, Jr., Chester; Richard G. Huff, Basking Ridge; Kenneth L. Walker, New Providence, all of N.J.

[73] Assignee: AT&T Corp., Murray Hill, N.J.

[21] Appl. No.: 317,409

[22] Filed: Oct. 3, 1994

Related U.S. Application Data

[60] Continuation of Ser. No. 164,525, Dec. 9, 1993, abandoned, which is a division of Ser. No. 924,278, Aug. 3, 1992, Pat. No. 5,298,047.

[51] Int. Cl.^{6} G02B 6/10

[52] U.S. Cl. 385/123; 385/111; 385/11; 65/432; 65/438

[58] Field of Search 385/123, 100, 110, 111, 385/113, 11, 15; 65/3.11, 10.1, 438, 432, 435; 359/494, 498, 885; 57/6, 7, 9, 293; 264/1.5; 356/73.1, 364

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European Search Repot, The Hague, Sep. 29, 1993, Examiner J. G. Stroud.

Primary Examiner—Frank Gonzalez
Assistant Examiner—Phan Thi Heartney Palmer
Attorney, Agent, or Firm—Eugen E. Pacher

[57] ABSTRACT

The presence of (typically unintended) birefringence in single mode optical fiber can severely limit the usefulness of the fiber for, e.g., high bit rate or analog optical fiber communication systems, due to the resulting polarization mode dispersion (PMD). It has now been discovered that PMD can be substantially reduced if, during drawing of the fiber, a torque is applied to the fiber such that a "spin" is impressed on the fiber. Desirably the torque is applied such that the spin impressed on the fiber does not have constant spatial frequency, e.g., has alternately clockwise and counterclockwise helicity. At least a portion of optical fiber according to the invention has spin alternately clockwise and counterclockwise.

4 Claims, 3 Drawing Sheets

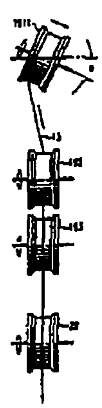

FIG. 1
(PRIOR ART)

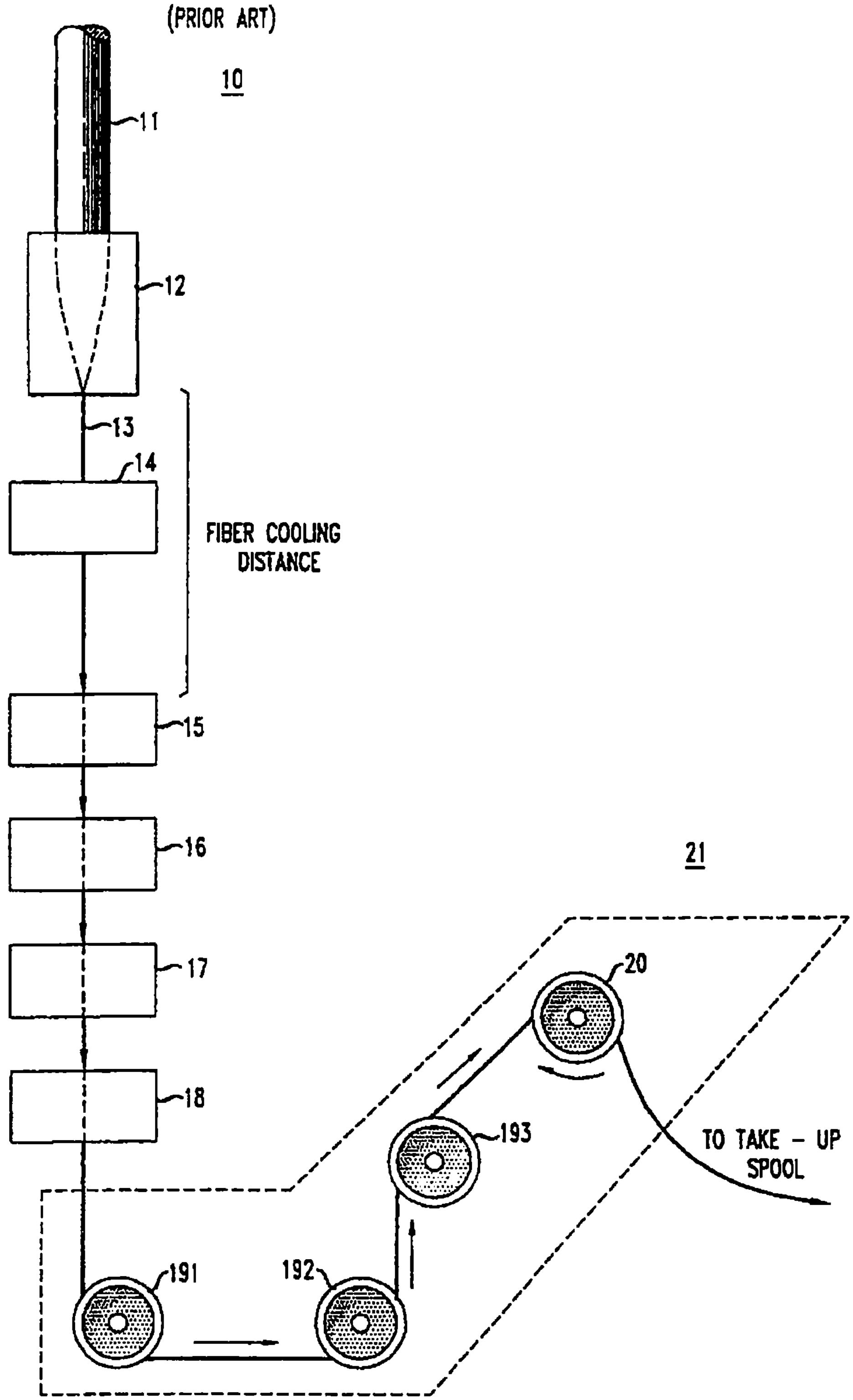

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FIG. 2
(PRIOR ART)

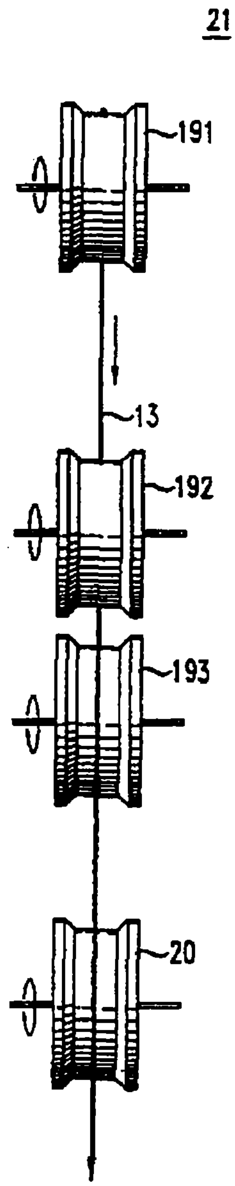

FIG. 3

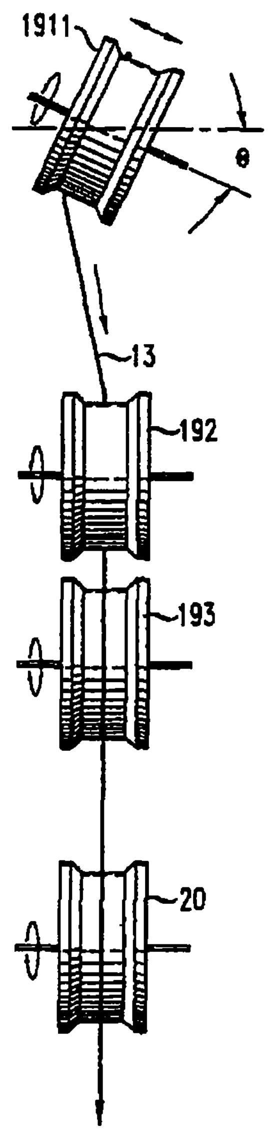

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FIG. 4

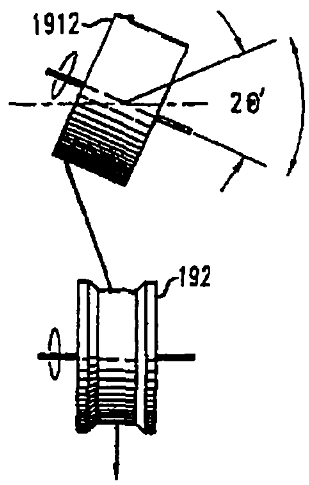


FIG. 5

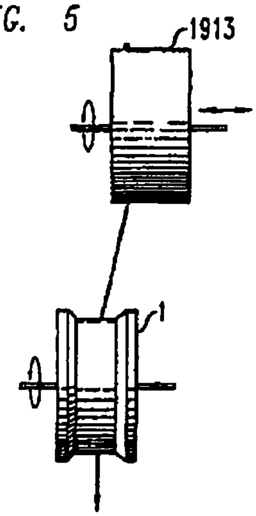


FIG. 6

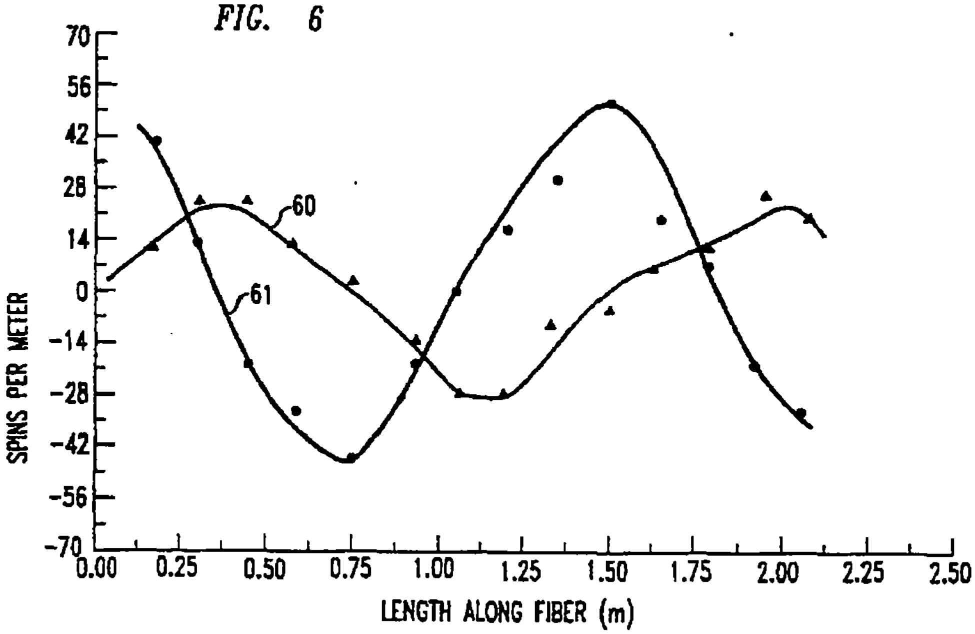
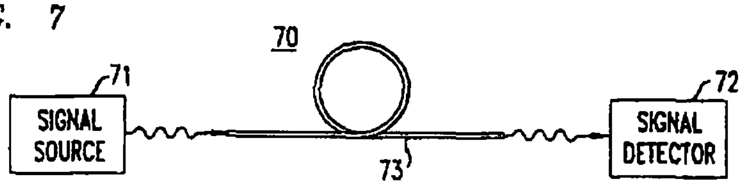


FIG. 7



ARTICLE COMPRISING OPTICAL FIBER HAVING LOW POLARIZATION MODE DISPERSION, DUE TO PERMANENT SPIN

This application is a continuation of application Ser. No. 08/164,525, filed on Dec. 9, 1993, now abandoned, which was a divisional application under 37 CFR 1.60, Ser. No. 07/924,278, filed Aug. 3, 1992, now U.S. Pat. No. 5,298,047.

FIELD OF THE INVENTION

This invention pertains to optical fibers, in particular, to single mode optical fiber having relatively low polarization mode dispersion (PMD). It also pertains to communication systems that comprise such fiber, and to methods of making such fiber.

BACKGROUND OF THE INVENTION

An ideal circularly symmetric "single mode" optical fiber can support two independent, degenerate modes of orthogonal polarization. Either one of these constitutes the fundamental HE_{11} mode. In general, the electric field of light propagating along the fiber is a linear superposition of these two polarization eigenmodes.

In practical single mode fiber, various imperfections such as asymmetrical lateral stress and a non-circular core typically break the circular symmetry of the ideal fiber and lift the degeneracy of these two polarization modes. The two modes then propagate with different phase velocities, and this difference between their effective refractive indices is called birefringence.

Fiber birefringence can result from either a geometrical deformation or from various elasto-optic, magneto-optic or electro-optic index changes. In so-called polarization-preserving fibers asymmetry is deliberately introduced into the fiber. However, in ordinary (non-polarization-preserving) fibers the birefringence mechanisms act on the fiber in substantially unpredictable manner. Thus, the polarization state of the guided light will typically evolve through a pseudorandom sequence of states along the fiber, with the polarization state at the fiber output typically being both unpredictable and unstable. On average, a given polarization state in a given fiber is reproduced after a certain length L_p, the polarization "beat" length associated with the given fiber.

The presence of birefringence in conventional single mode fiber results in signal dispersion (so-called polarization mode dispersion or PMD) and thus typically is undesirable, especially for applications that involve high bit rates or analog transmission (e.g., for optical fiber analog CATV systems).

It is known that fiber having low PMD can be produced by rapidly spinning the preform while pulling the fiber from the preform. The prior art teaches that this results in periodically interchanged fast and slow birefringence axes along the fiber, which can lead to very low net birefringence due to piecemeal compensation of the relative phase delay between the polarization eigenmodes, provided the spin pitch is much less than the "un-spun" fiber beat length. See, for instance, A. Ashkin et al., *Applied Optics*, Vol. 20(13), p. 2299; A. J. Barlow et al., *Applied Optics*, Vol. 20(17), p. 2962; and S. C. Rashleigh, Laser Focus, May 1983.

It is primarily the prior art requirement that the spin pitch be much less than the "unspun" L_p which makes the prior art technique substantially unsuitable for current commercial fiber production. For instance, assuming that the unspun L_p is about 1 m and the draw speed is 10 m/seconds, then the preform has to be spun at 6000 rpm in order to yield a spin pitch that is 1/10th of the unspun L_p. This is typically not practical in commercial fiber production.

In view of the commercial significance of low birefringence optical fiber, it would be highly desirable to have available a technique for producing such fiber that is compatible with current commercial practice, e.g., that is usable even at the high draw speeds that are typically used now. This application discloses such a technique.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically depicts exemplary prior art fiber draw apparatus;

FIG. 2 shows, schematically and in top view, the guide portion of the apparatus of FIG. 1;

FIGS. 3–5 depict, also schematically and in top view, exemplary guide portions that can be used to practice the invention;

FIG. 6 shows exemplary data on spin vs. distance along the fiber, for fiber according to the invention; and

FIG. 7 schematically depicts an exemplary optical communication system according to the invention.

THE INVENTION

Broadly speaking, the invention is embodied in a novel and convenient method of making optical fiber, typically single mode fiber, that can be used to produce fiber having low PMD, exemplarily less than 0.5 ps/km$^{\frac{1}{2}}$. It is also embodied in a novel type of low PMD fiber, and in articles (e.g., an optical fiber communication system) that comprise such fiber.

More specifically, the inventive method comprises providing a conventional optical fiber preform, heating at least a portion of the preform to a conventional draw temperature, and drawing optical fiber from the heated preform in such a way that a spin is impressed on the fiber. Significantly, a torque is applied to the fiber such that the fiber is caused to twist around its longitudinal axis, with a resulting torsional deformation of the fiber material in the hot zone.

A spin is "impressed" on the fiber herein if fiber material in the hot zone is caused to be torsionally deformed, with that deformation being frozen into the fiber, such that the fiber exhibits a permanent "spin", i.e., a permanent torsional deformation. The existence of such a frozen-in spin can be readily ascertained, e.g., by microscopic examination of the fiber to determine rotation of core ovality or eccentricity, or by means of a traveling magneto-optic modulator, as used by M. J. Marrone et al., *Optics Letters*, Vol. 12(1), p. 60. Associated with such a frozen-in spin is a pitch, the spin repeat distance along the fiber.

As will be readily appreciated by those skilled in the art, the prior art method of spinning the preform results in a spin of essentially constant pitch. It is known that small twists of the symmetry axes can occur during the drawing process such that even conventional single-mode fibers exhibit a variation in the optical polarization along the fiber. See, for instance, the above cited Marrone et al. paper. However, we know of no case of prior art fiber with unintended spin whose spin had a spatial frequency in excess of 4 spins/meter. See, for instance, M. J. Marrone et al., op. cit., Table 1. Fiber having such low spin typically does not exhibit com-

mercially significant reduction in PMD. Thus, fiber according to the invention comprises a portion or portions having spin spatial frequency in excess of 4 spins/meter, preferably in excess of 10 or even 20 spins/meter.

In currently preferred embodiments of the invention, the torque is applied intermittently to the fiber, whereby the spin impressed on the fiber has a pitch that is not constant over substantial lengths of fiber, e.g., is not constant over the beat length L_p. We currently believe that non-constant pitch can have advantages over constant pitch, since low pitch can also couple the two polarization modes, provided the pitch is precisely matched with the fiber birefringence spatial frequency. See, for instance, S.C. Rashleigh,

J. of Lightwave Technology, Vol. LT-1(2), pp. 312–331, especially p. 320, where it is stated that, "... regardless of the actual distribution f(z) of the birefringence perturbations, only the one spectral component with frequency β_l can couple the two polarization eigenmodes. All other spectral components do not efficiently couple the modes". The parameter β_l is the intrinsic birefringence of the fiber, and $F(\beta_l)$ is the Fourier transform of f(z). Since the perturbation f(z) is essentially random, it is clear that a constant pitch spin will typically not result in efficient mode coupling. On the other hand, non-constant pitch spin, especially spin that has alternately positive and negative helicity, is likely to contain spatial components that produce efficient coupling. We currently believe that strong coupling can be obtained with spin of varying spatial frequency that comprises, in addition to regions of relatively high spin spatial frequency, regions of relatively low spin spatial frequency. This is, for instance, the case if the spin alternates between positive and negative helicity.

The invention is also embodied in optical fiber (exemplarily SiO_2-based fiber comprising a core and a cladding, with the former having larger effective refractive index than the cladding material that surrounds the core) that is produced by the inventive method. It is also embodied in an article (e.g., an optical fiber communication system that comprises a source of an optical signal, means for detecting an optical signal, and an optical fiber according to the invention signal-transmissively connecting the detector means and the source. More specifically, a spin is impressed on the fiber, with the spin not being constant along the fiber, and with at least a portion of the fiber having a spatial spin frequency in excess of 4 spins/meter.

FIG. 1 schematically depicts conventional (prior art) drawing apparatus 10. Fiber preform 11 is slowly fed (by means of a feed mechanism that is not shown) into furnace 12, where fiber 13 is drawn from the necked down portion of the preform. The bare fiber passes through diameter monitor 14 into coating applicator 15, wherein the polymer coating (frequently comprising an inner and an outer coating) is applied to the, by now relatively cool, bare fiber. After passing through coating concentricity monitor 16 the fiber passes through curing station 17. Exemplarily 17 comprises UV lamps. Downstream from 17 is coating diameter monitor 18, followed by guide means (e.g., rollers 191, 192, 193) and drive means (e.g., pulling capstan 20) in region 21. It will be noted that guide roller 191 is the first contact point of the fiber with a solid. At this point the fiber is already protected by a cured polymer coating. It will also be noted that the draw force is provided by capstan

20, and that the rotational speed of 20 determines the draw speed, which exemplarily can be as high as 20 m/second. From 20 the fiber typically is lead to (independently driven) take-up means, e.g., a take-up spool. Those skilled in the art will recognize that FIG. 1 shows several optional features (e.g., 14, 16, 18), and does not show all possible features (e.g., a hermetic coating chamber between 12 and 15). However, FIG. 10 exemplifies currently used conventional drawing apparatus.

In the prior an apparatus of FIG. 1 the fiber essentially moves in a single plane at least between its point of origin in the furnace and the capstan, and no twist is intentionally impressed on the fiber. See FIG. 2, which is a schematic top view of portion 21 of the apparatus of FIG. 1.

According to the invention, a torque is applied to the fiber such that a spin is impressed on the fiber. Although in principle the torque could be applied at any downstream point (prior to take-up) at which the fiber has cooled sufficiently to be contacted, it is generally not desirable to contact the bare fiber. Thus, the torque advantageously is applied at a point downstream from curing station 17, typically at an appropriate point in region 21. It is currently most preferred to apply the torque by means of the first guide roller.

We have discovered that an intermittent torque can be applied to the fiber, such that a twist with non-constant pitch is impressed on the fiber. This can, for instance, be accomplished by changing the orientation of guide roller 1911 of FIG. 3, exemplarily by canting the roller by an angle θ around a direction parallel to the draw tower axis. Canting roller 1911 as indicated causes the fiber to oscillate back and forth on the roller, in response to lateral forces that automatically arise in this arrangement. More specifically, the lateral forces translate into a torque on the fiber, which causes the fiber to roll laterally on roller 1911, thereby moving the fiber out of the plane defined by the fiber in the prior an (un-canted) apparatus. It will be appreciated that the lateral roll is superimposed on the conventional draw motion. The lateral motion of the fiber is believed to give rise to a restoring force that increases with increasing lateral displacement of the fiber, causing the fiber to jump back (substantially, but not necessarily exactly) into the plane, only to immediately begin another sidewise roll. This non-symmetrical back-and-forth motion is indicated by the double-headed arrow adjacent to roller 1911 in FIG. 3. The angular rotation speed of the fiber during the lateral roll is, inter alia, a function of the cant angle θ. Thus, the pitch of the spin impressed on the fiber is also a function of θ. For instance, particular draw apparatus used by us yielded average pitches of 14 and 7 cm for $\theta = 7$ and 15°, respectively. It will be appreciated that these values are exemplary only, since the pitch will depend, inter alia, on the configuration and height of the draw tower, the draw speed, the draw tension and the coating viscosity.

Those skilled in the art will recognize that the described exemplary method not only impresses a spin on the fiber but also introduces a substantially equal and opposite (generally elastic) twist into the taken-up fiber. Although such fiber may be acceptable for some purposes (e.g., for sensor purposes that require only a relatively short length of fiber), it will generally be desirable to remove (or prevent the introduction of) the unwanted elastic twist. The elastic twist can, for instance, be removed by appropriate respooling. However, it is preferable to substantially prevent introduc-

tion of the elastic twist. This can be accomplished by alternately imposing a clockwise and a counterclockwise torque on the fiber, exemplarily as described below.

Causing the guide roller 1912 of FIG. 4 to oscillate about an axis that is parallel to the fiber draw direction (which is typically the same as the draw tower axis) alternately impresses positive and negative spin on the fiber. Furthermore, the resulting positive and negative elastic twists on the fiber substantially cancel, such that the fiber on the take-up spool is substantially free of torsional elastic strain. Guide roller 1912 of FIG. 4 can be caused to oscillate back and forth by any appropriate means, e.g., by eccentric drive means (not shown). An alternate arrangement is schematically shown in FIG. 5, wherein guide roller 1913 is caused to move back and forth axially, by appropriate conventional means that are not shown, resulting in alternate application of clockwise and counterclockwise torque on the fiber.

Those skilled in the art will recognize that the guide and drive means 21 of FIG. 1 can take many forms. For instance, sheaves (as shown in FIGS. 1-3) may be used, or ungrooved rollers may be used, or sheaves and ungrooved rollers may be used in combination (exemplarily as shown in FIGS. 4 and 5). All appropriate guide and drive means are contemplated, as are all appropriate means for applying an appropriate torque to the fiber.

FIG. 6 shows exemplary experimental data, namely, the spin spatial frequency (in spins/m) as a function of distance along the fiber. Curve 60 was obtained from a single mode fiber which was drawn at 1.5 m/second, with 60 cycles/minute of the oscillating guide roller 1912 of FIG. 4), and curve 61 from an otherwise identical single mode fiber which was drawn at 3 m/second, with 106 cycles/minute of roller 1912. As can be seen from FIG. 6, each of the fibers contains portions whose spin spatial frequency is far in excess of 4 spins/m (even in excess of 20 spins/m), and in each of the fibers the spin is non-constant, even having clockwise and counterclockwise helicity, resulting in substantial likelihood that the spin comprises a component that is effective in coupling the two polarization modes.

Those skilled in the art will appreciate that the pitch of the spin impressed on fiber drawn in apparatus of the type shown in FIG. 4 depends, inter alia, on the oscillation amplitude $2\theta'$ and the oscillation frequency. For instance, in a particular fiber draw apparatus according to the invention θ' was about 15°, and the oscillation frequency was about 106 cycles/minute. These values are exemplary only, and those skilled in the art will, aided by the teachings herein, be able to not only adapt their draw apparatus to practice the invention but also to select draw parameters that are suitable for their particular apparatus. FIG. 7 shows an exemplary optical communication system 70 according to the invention wherein numerals 71-73 refer, respectively, to an optical signal source, an optical signal detector, and optical fiber that signal transmissively connects source and detector.

We claim:

1. An article comprising optical communication fiber with a spin impressed on the fiber; CHARACTERIZED IN THAT the fiber is single mode optical fiber; and in at least a portion of the fiber the spin impressed on the fiber is alternately clockwise and counterclockwise, with a spin repeat distance of at most 20 m.

2. Article according to claim 1, wherein said single mode optical fiber has a polarization mode dispersion (PMD), with the PMD of the fiber being less than 0.5 ps/km$^{\frac{1}{2}}$.

3. Article according to claim 2, wherein the article is an optical communication system that comprises an optical signal source a length of optical fiber comprising said single mode optical fiber and an optical signal detector, with said length optical fiber signal-transmissively connecting said source and said detector.

4. Article according to claim 1, wherein the repeat distance is at most 13.2 m.

* * * * *

EXHIBIT / ATTACHMENT

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United States Patent [19]
MacChesney et al.

[11] **Patent Number:** 4,909,816
[45] **Date of Patent:** Mar. 20, 1990

[54] **OPTICAL FIBER FABRICATION AND RESULTING PRODUCT**

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[73] Assignee: American Telephone and Telegraph Company, AT&T Bell Laboratories, Murray Hill, N.J.

[21] Appl. No.: 517,430

[22] Filed: Jul. 26, 1983

Related U.S. Application Data

[63] Continuation of Ser. No. 382,401, May 26, 1982, abandoned, which is a continuation of Ser. No. 147,934, May 8, 1980, abandoned, which is a continuation of Ser. No. 828,617, Aug. 29, 1977, Pat. No. 4,217,027, which is a continuation of Ser. No. 444,705, Feb. 22, 1974, abandoned.

[51] Int. Cl.^{4} C03B 37/025; C03B 37/075
[52] U.S. Cl. 65/3.12; 65/3.11; 65/3.2; 65/18.2; 350/96.30; 427/163; 427/167
[58] Field of Search 350/96.30, 96.31; 65/3.12, 3.11, 3.2, 18.2, 110; 427/163, 167, 231, 237; 264/1.2, 1.5

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Primary Examiner—Kenneth M. Schor
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[57] **ABSTRACT**

A preform for fabrication of a glass fiber optical transmission line is prepared by chemical reaction of vapor ingredients within a glass tube. Reaction, which may be between chlorides or hydrides of, for example, silicon and germanium with oxygen, occurs preferentially within a constantly traversing hot zone. Flow rates and temperature are sufficient to result in glass formation in the form of particulate matter on the inner surface of the tube. The particulate matter deposits on the tube and is fused with each passage of the hot zone. Continuous rotation of the tube during processing permits attainment of higher temperatures within the heated zone without distortion of the tube.

17 Claims, 2 Drawing Sheets

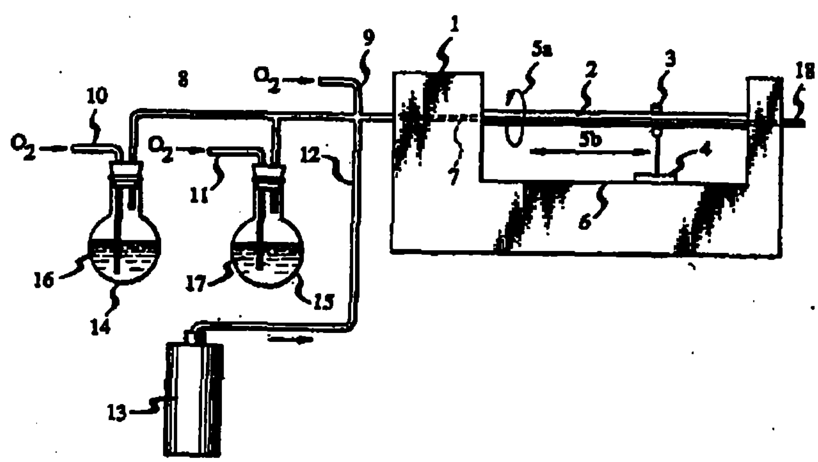
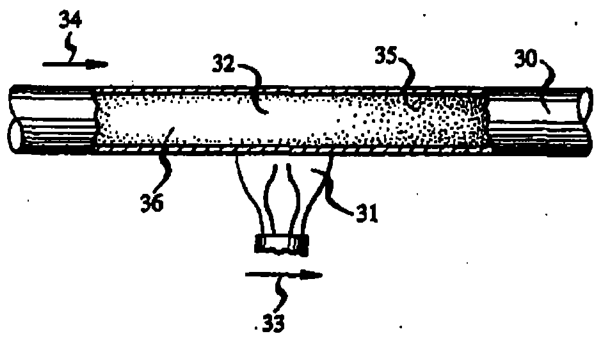


FIG. 3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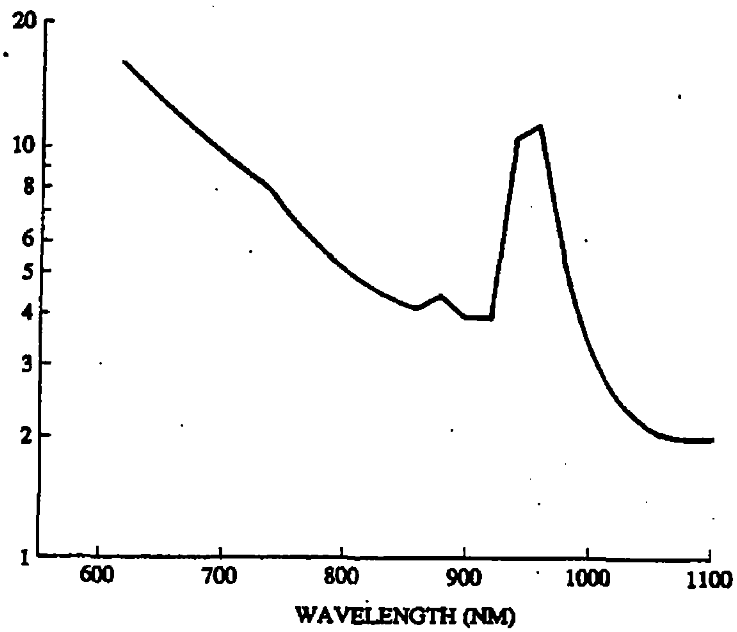
33

FIG. 4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10
8
6
5
4
3
2
1
600
700
800
900
1000
1100
WAVELENGTH (NM)

OPTICAL FIBER FABRICATION AND RESULTING PRODUCT

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of application Ser. No. 382,401, filed May 26, 1982, now abandoned, which was a continuation of application Ser. No. 147,934, filed May 8, 1980, now abandoned, which was a continuation of application Ser. No. 828,617, filed Aug. 29, 1977, now U.S. Pat. No. 4,217,027, which was a continuation of application Ser. No. 444,705, filed Feb. 22, 1974, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is concerned with fibers for use in transmission lines in communications systems operating in the visible or near visible spectra. Such fibers are generally clad for guiding purposes so that refractive index decreases in value from the core center to the periphery either as a step function or as a continuous gradient.

2. Description of the Prior Art

"Optical" communications systems, that is systems operating in the visible or near visible spectra, are now at an advanced stage of development. In accordance with the view held by many, commercial use may be expected within a period of about five years.

A system most likely to find initial, and probably long term, use utilizes clad glass fibers as the transmission medium. These fibers, generally having an overall cross-sectional diameter of about 100 mm, are generally composed of at least two sections: core and cladding. The cladding layer is necessarily of lowered refractive index relative to the core with typical index variation from core to clad being in the range from about 0.01 to 0.05. Structures under study may be single mode or multimode. The former is characterized by a sufficiently small core section to efficiently accommodate only the first order mode. Such structures may have a core about 1 or 2 μm. Multimode lines typically have core sections from 50 μm to 85 or 90 μm in diameter.

Multimode structures appear to be of somewhat greater interest at this time. The greater core section facilitates splicing and permits more efficient energy coupling to source and repeater. Introduction of many modes into or, alternatively, generation of many modes within the line does give rise to a dispersion limitation which takes the form of a smearing due to the differing velocities of different order modes. Mode dispersion effects have been minimized by a continuous focusing structure. This structure takes the form of a fiber, the index of which is graded generally exponentially from a high value at the core center. The fundamental mode which traverses the length of material is generally confined to the highest index (lowest velocity) region, while higher order modes as path length increases spend longer and longer periods in relatively low index (high velocity) regions.

A number of procedures have been utilized for fabricating clad glass fibers. Most have yielded to procedures which in some way involve vapor source material. So, typically, chlorides, hydrides, or other compounds of silica, as well as desired dopants, tailoring the index, are reacted with oxygen to produce deposits which directly or ultimately serve as glass source material from which the fiber is drawn. Dopant materials include compounds of, for example, boron for lowering index and germanium, titanium, aluminum, and phosphorus for increasing index. Where the ultimate product is to be a graded multimode line, index gradation may be accomplished, for example, by altering the amount or type of dopant during deposition.

One procedure utilizing vapor source material is chemical vapor deposition (CVD). In this procedure, compounds are passed over a heated surface—e.g., about a rod or within a tube. Temperatures and rates are adjusted so that reaction is solely heterogeneous, i.e., occurs at the heated surface so that the initial material is a continuous glass layer.

An alternative procedure results in the introduction of such precursor materials into a flame produced by ignition of a gaseous mixture of, for example, methane and oxygen. Reaction is, in this instance, homogeneous resulting in formation of glassy particles within the flame. Combustion product and glassy particles then form a moving gas stream which is made incident again on a heated surface, such as a rod or tube. Adherent particles sometimes called "soot" are in subsequent processing flushed, and are sintered and fused to result in a glassy layer.

The CVD process has advantages including high purity but suffers from prolonged required deposition periods. Typically, a suitable preform adequate for fabrication of a kilometer of fiber may require periods of a day or longer.

The soot process has the advantage of high speed; preforms adequate for fabrication of a kilometer of fiber may be prepared in a few hours or less. Disadvantages, however, include at least initial introduction of contaminants, such as solid carbonaceous residue. Since formation takes place within the combustion environment, hydration is inevitable; and this gives rise to the well-known water absorption peaks with their related subharmonics so consequential in various portions of the infrared spectrum.

Both procedures are now an established part of the art. See, for example, U.S. Pat. Nos. 3,711,262, 3,737,292, and 3,737,293. Modifications in the processes have, to some extent, increased the speed of the CVD process and reduced the effects of contamination by hydration in the soot process. Fibers a kilometer or more in length with losses as low as 2 or 3 db/kilometer in selected regions of the infrared are now regularly produced in pilot operations.

SUMMARY OF THE INVENTION

The invention provides for fabrication of clad glass fibers by a procedure which combines some of the advantages of the prior art CVD and soot processes. Generally, gas phase precursor reactants together with oxygen are introduced into a glass tube in the form of a constantly moving stream. Tube and contents are heated to homogeneous reaction temperature within a moving hot zone produced by a moving heating means constantly traversing the outside surface of the tube. Homogeneously produced glass particles ("soot") collect on the tube walls, and are fused into a continuous layer within the moving hot zone.

With usual heating means there is simultaneous heterogeneous reaction so that a glassy layer is produced within the moving hot zone by reaction at the heated wall surface. This deposit, which is present under ordi-

nary circumstances, is identical to the layer produced in the normal CVD processing.

In accordance with the preferred embodiment, the tube within which formation is taking place is continuously rotated about its own axis. For example, at a speed of 100 rpm, uniformity about the periphery is enhanced. The surface produced by the molten CVD layer may help to hold the "soot" particles during fusion.

Reactant materials include chlorides and hydrides, as well as other compounds which will react with oxygen as described. As in other vapor reaction processes, other gaseous material may be introduced, for example, to act as carrier or, in the instance of extremely combustible matter such as hydrides, to act as a diluent.

Continuous fusion within the hot zone and the resultant thickness uniformity of deposit facilitates formation of graded index structures. As in CVD, gradients may be produced by varying reactant composition with the ratio of high index-producing dopant increasing, in this instance, with successive hot zone traversals. Since reaction conditions for different constituents in the reactant mix are different, it is possible also to produce a gradient by altering temperature and/or flow rate during processing.

Typical reaction temperatures maintained at least at the tube wall are within the range of from 1200 to 1600 degrees C. These temperatures, high relative to CVD, are responsible for rapidity of preform production. Particularly at the high temperature end of the range, distortion of the usually silica tube is avoided by rotation. Narrow zones, increased rotation speed, and vertical disposition of the tube may all contribute to the avoidance of tube distortion.

Preforms adequate for preparation of one or a few kilometers of fiber may be prepared during deposition periods of one or a few hours. These preforms are prepared by conventional processing from the deposited product to a final configuration which, as presently practiced, may be of rod shape with an internal diameter of from 4 to 8 mm and a length of 18 inches. In usual processing, the tube which served as the deposition substrate becomes the clad. It may, in accordance with the system, be composed of pure silica or of silica which has been doped to alter, generally to reduce its index. Variations may include removal of the tube, as well as deposition of additional material on the outer surface. The tube serving as the substrate during deposition may be retained to serve as a clad, may be removed, or may, during simultaneous deposition, on its outer surface be provided with encompassing layer/s.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a front elevational view of apparatus suitable for practice of the deposition process in accordance with the invention;

FIG. 2 is a front elevational view of apparatus alternative to that of FIG. 1;

FIG. 3 is a front elevational view of a section of tubular material depicting observed conditions during processing; and

FIG. 4, on coordinates of insertion loss in units of dB/kilometer and wavelength in nanometers, is a plot showing the relationship of those two parameters for a clad multimode fiber produced in accordance with the invention.

DETAILED DESCRIPTION

1. The Drawing

FIG. 1 depicts a lathe 1 holding substrate tube 2 within which a hot zone 3 is produced by heating means 4. Tube 2 may be rotated, for example, in the direction shown by arrow 5a by means now shown and hot zone 3 is caused to traverse tube 2 by movement of heating means 4 as schematically depicted by double headed arrow 5a, for example, by a threaded feed member 6. A gaseous material is introduced into tube 2 via inlet tube 7 which is, in turn, connected to source material reservoirs 8. Such reservoirs may include an oxygen inlet 9 connected to means not shown. As depicted, gaseous material may also be introduced by inlets 10 and 11 by means not shown and through inlet 12 from reservoir 13. Reservoirs 14 and 15 contain normally liquid reactant material which is introduced into tube 2 by means of carrier gas introduced through inlets 10 and 11 with the arrangement being such that the carrier gas is bubbled through such liquids 16 and 17. Exiting material is exhausted through outlet 18. Not shown is the arrangement of mixing valves and shut off valves which may be utilized to meter flows and to make other necessary adjustments in composition. The apparatus of FIG. 1 is generally horizontally disposed.

The apparatus of FIG. 2 is, in its operational characteristic, quite similar to that of FIG. 1. Vertical disposition of the substrate tube, however, lends stability to the portion of the tube within the hot zone and may permit attainment of higher temperature or of longer hot zones in the traversal direction without objectionable distortion. Apparatus depicted includes tube 20 which may optionally be provided with rotation means not shown. This tube is secured to the apparatus by means of chucks 21 and 22 and a traversing hot zone is produced within tube 20 by means of a ring burner 23 which is caused to constantly traverse tube 20 in the direction depicted by double headed arrow 24 by moving means 25. Gaseous material, for example, from source such as 8 of FIG. 1 is introduced via inlet tube 26 and exiting material leaves via exhaust 27.

FIG. 3 is a front elevational view of a section of a substrate tube 30 as observed during deposition. Depicted is a heating means 31 producing a hot zone 32 which is traversing tube 30 in the direction shown by arrow 33 by means now shown. Gaseous material is introduced at the left end of tube 30 and flows in the broken section of the FIG. in the direction shown by arrow 34. For the processing conditions, which with respect to traversal direction and hot zone temperature are those of Example 1, two regions are clearly observable. Zone 35 downstream of hot zone 32 is filled with a moving powdery suspension of particulate oxidic material, while region 36, devoid of such particulate matter, defines the region within which fusion of deposited material is occurring.

FIG. 4 is a plot for measured loss in units of dB/kilometer as measured on 713 meters of fiber prepared in accordance with an Example herein. Abscissa units are wavelength in nanometers. It is seen that loss is at a minimum of about 2 dB/kilometer for the wavelength range of about 1060 to 1100 nm (the limiting value on the plot). The peak at about 950 nm, as well as those at 880 and 730 nm, are characteristic sub-harmonics of the fundamental water absorption.

2. Processing Requirements

a. Reaction Temperature

Superficially, the inventive technique resembles conventional chemical vapor deposition. However, whereas CVD conditions are so arranged that deposi-

tion is solely the result of heterogeneous formation at a heated substrate surface, procedures of this invention rely upon significant homogeneous reaction. In general, 50 percent or more of reaction product is produced in a position removed from substrate surface and results in the formation of solid oxidic particles of the desired glass composition. These particles are similar to those produced during the "soot" process.

Homogeneous reaction is the result of sufficient rate of reactant introduction and sufficient reaction temperature. Such conditions may be achieved simply by increasing one or both parameters until homogeneous reaction is visually observed. To optimize the process from the standpoint of reaction, high temperatures are utilized. For the usual silica based systems which comprise the preferred embodiment, temperatures at least at the substrate wall are generally maintained at a minimum of 1200 degrees C. at the moving position corresponding with the hot zone. Maximum temperatures are ultimately limited by significant wall distortion. For horizontally disposed apparatus, such as that shown in FIG. 1, in which a hot zone of the length of approximately 2 cm moves at the rate of about 45 cm/min within a tube rotated at the rate of about 100 rpm, a temperature of 1600 degrees C. may be produced without harmful tube distortion. Decreasing the length of the hot zone, increasing the rate of rotation, increasing reactant flow rate, vertical disposition of the tube, are all factors which may permit use of higher maximum temperatures without variation in tube geometry. Indicated temperatures are those measured by means of an optical pyrometer focused at the outer tube surface. It has been estimated that for typical conditions the thermal gradient across the tube may be as high as 300 degrees C.

b. Flow Rates

This parameter, like temperature, is dependent upon other processing conditions. Again, a minimum acceptable rate for these purposes may be determined by visual observation. Highest flow rates are for those materials which by virtue of combustibility, high vapor pressure, etc., are diluted to a significant extent by inert material. Examples are the hydrides where dilution frequently is as high as 99.5 volume percent based on the total reactant content may necessitate a linear flow rate of at least 1 meter per second. Chlorides, which do not present this problem, need not be diluted to avoid combustion. Inert material, such as nitrogen or helium, is introduced solely for transfer purposes and need be present only in amount typically of up to 10 percent by volume. Flow rates are, as indicated, temperature dependent, with the required homogeneous reaction taking place at acceptable rate only by an increase flow of about 50 percent for each hundred degree increase in reaction temperature.

c. Reactants

Examples were carried out using chlorides and hydrides. Other gaseous materials of sufficient vapor pressure under processing conditions which react with oxygen or oxygen bearing material to produce the required oxidic glass may be substituted. In a typical system, the substrate tube is silica–generally undoped. Where this tube is of ordinary purity, first reactant introduced may be such as to result in the formation of a first layer of undoped silica or doped with an oxide such as B_2O_3 which serves to lower the refractive index, which acts as a part of the clad and presents a barrier to diffusing impurity from the tube. It may be considered that,

under these circumstances, the substrate tube ultimately serves as a mechanical support rather than as an optical cladding. Subsequent to formation of this first barrier layer or absent such procedure, where the tube is of sufficient purity, reactant materials of such nature as to result in the desired index-increased core are introduced. In a chloride system, these may take the form of a mixture of $SiCl_4$ together with, for example $GeCl_4$, and oxygen. Chlorides of other index increasing materials, such as phosphorus, titanium, and aluminum may be substituted for $GeCl_4$ or admixed. BCl_3 may also be included perhaps to facilitate glass formation because of lowered fusion temperature; or because of refractive index lowering, the initial mixture may be altered during successive hot zone traversals so as to increase index (by increasing $GeCl_4$ or other index-increasing dopant precursor or by decreasing BCl_3).

Since the usual vapor phase glass precursor compounds are not oxidic, oxygen or a suitable oxygen bearing compound is generally included to form the ultimate oxidic glass. A satisfactory procedure, followed in exemplary procedures, takes the form of an oxygen stream bubbled through reservoirs of liquid phase glass forming compounds. In one procedure, for example, oxygen streams were bubbled through silicon tetrachloride, and through germanium tetrachloride. These streams were then combined with vapor phase boron tetrachloride and additional oxygen, the resultant mixture being introduced into the reaction chamber.

Relative amounts of glass forming ingredients are dependent upon a variety of factors, such as vapor pressure, temperature, flow rate, desired index, etc. The appended examples indicate suitable amounts for producing the noted indices under the noted conditions. Variants are known to those familiar with glass forming procedures.

A variety of diluent materials may be utilized for any of the noted reasons so, for example, argon, nitrogen, helium, etc., may serve to maintain desired flow rates to prevent precombustion, etc. Oxygen bearing compounds which may replace oxygen in whole or in part include N_2O, NO, and CO_2.

In general, concentration of 3d-transition metal impurities in the gas stream is kept below 10^{-2} percent, although further reduction in loss accompanies reduction of those impurities down to the part per billion range. Such levels are readily available from commercial sources or by purification by means similar to those taught by H. C. Theuerer, Pat. No. 3,071,444. As compared with the usual soot process, the inventive procedure is carried out in a controlled environment without direct exposure to combustion products. This inherently results in avoidance of inclusion of particulate combustion products. Where desired, hydration resulting from combustion in the soot process may be minimized. This is a particularly significant advantage for operation in several portions of the infrared spectrum which suffers from sub-harmonics of the fundamental H_2O absorption. Water vapor may, therefore, be a particularly significant impurity and, for many purposes, should be kept to a level below a few ppm by volume.

3. General Procedure

The procedure described is that which was followed in Examples 1 through 4. Deposition was carried out within a 12 I.D. by 14 O.D. mm silica tube. The tube was placed on a glass lathe within which it was rotated at 100 rpm. Before introduction of reactants, it was flushed with a continuous stream of oxygen while tra-

versing with an oxyhydrogen burner sufficient to bring the wall temperature to 1400 degrees C. The purpose was to remove any volatile impurities on the inside wall of the tube.

Following a period of 5 minutes, a mixture of oxygen, $SiCl_4$, and BCl_3 replaced the oxygen flow. The composition of approximately 10 percent $SiCl_4$, 3 percent BCl_3, remainder oxygen, maintaining temperature at 1400 degrees C. within the moving hot zone as measured at the wall. In this particular example, the zone was moved at a speed of approximately 45 cm/min in the forward direction (direction of gas flow) and was rapidly returned to its initial position (approximately 30sec. elapsed time to the beginning of the slow traversal).

Formation of flaky material within the tube, at a position spaced from the wall generally downstream of the hot zone, was visually observed. It was deduced and verified that homogeneous reaction was largely within the zone with particulates being carried downstream by the moving gas. Deposition was continued for approximately twenty minutes following which flow of chloride reactants was discontinued. Oxygen flow was continued for several passes of the hot zone.

The procedure to this point results in deposition of a layer serving as cladding. Core material was next deposited by introduction of $SiCl_4$ and $GeCl_4$. These reactants, too, were introduced with an oxygen carrier, as before. With the temperature of the hot zone increased somewhat to about 1450 degrees C., deposition was continued for about one hour.

In this particular example, tube collapse was initiated with reactants still flowing simply by reducing the rate of traverse of the hot zone. This resulted in a temperature increase which ultimately attained a level of about 1900 degrees C. to produce nearly complete collapse. Reactant flow was then stopped with final collapse producing a finished preform consisting of a GeO_2-SiO_2 core with a borosilicate cladding supported, in turn, by a silica layer. It will be recognized by those skilled in the art of fiber drawing, that the tube, without first being collapsed, can also be drawn into acceptable fiber. The resulting preform was then drawn to result in a fiber having an overall diameter of approximately 100 μm with a core area defined as the region within the borosilicate layer having a diameter of approximately 37 μm. The length of fiber drawn was approximately 0.7 km. The method described in some detail in N. S. Kapany, *Fiber Optics Principles and Applications* (Academic Press, N.Y.) (1967) pages 110–117, involved the local heating of an end of the preform which was affixed to the fiber, which was, in turn, drawn at a constant velocity of approximately 60 meters/min by winding on a 30 cm diameter mandrel rotating at 60rpm.

The above description is in exemplary terms and is usefully read in conjunction with the appended examples. The inventive process departs from conventional CVD as described—i.e., in that reactant introduction rate and temperature are such as to result in homogeneous reaction to produce oxidic particles within the space enclosed, but separated from the walls of a tube. This, when combined with a moving hot zone, results in rapid preparation of a high quality preform as described. The moving hot zone is responsible for (1) homogeneous reaction; (2) to a large extent, the adherence of oxidic particles to the wall; and (3) fusion of the deposited particles and CVD-produced layer into a unitary, homogeneous glassy layer. In general, it is desirable to maintain the hot zone as short as possible depending upon constancy of traversal speed to result in uniform layer production. Motion of the hot zone should be such that every portion of the tube is heated to the zone temperature for the same period of time. This is easily accomplished by passing the heating means through a traversal distance which extends beyond the tube at both ends. Experimentally, hot zones of the order of 2 cm length (defining the heated region extending 4 cm on either side of the peak) have resulted in uniform coating under all experimental conditions. While, in principle, heating the entire tube may result in uniformity of deposition approaching that attained by use of a moving zone, very high flow rates are required to avoid inhomogeneity and differing thickness of deposit along the length of the tube.

4. Examples

The following example, utilizing chloride or hydride reactants, are set forth. The selection was made with a view to demonstrating a wide variety of compositions and different types of optical waveguide preforms for which the procedure can be used.

The tube of commercial grade fused quartz was first cleaned by immersion in hydrofluoric acid-nitric acid solution for three minutes and was rinsed with deionized water for a period of one hour. Tubing was cut into 18" lengths, and such sections were utilized in each of the examples. The substrate tube was provided with appropriate input and exhaust sections, and was heated with a moving oxyhydrogen torch producing a hot zone which traversed the tube in from one to eight minutes. In each instance, flushing was by oxygen at a flow rate of between 100 and 500 cm^3/min corresponding with a linear rate of 4.5 meter/mins, and this flushing was continued for several traversals of the zone.

EXAMPLE 1

The fused quartz tube used in this example was 12 mm I.D. × 14 mm O.D. Initial deposition was of a cladding material, SiO_2-B_2O_3, by introduction of 41 cm^3/min. $SiCl_4$, 12.5 cm^3/min BCl^3, both carried by oxygen such that the total oxygen flow was 250 cc/min. Sixteen passes of the hot zone were made at a temperature of 1430 degrees C. Core material was next deposited by flows of 32 cc/min $SiCl_4$, 48 cc/min $GeCl_4$, and oxygen 650 cc/min. This was continued for 68 minutes and temperatures of the hot zone were maintained at 1460 degrees C. Remaining steps, including partial collapse with flowing gas and final collapse under no flow conditions, were as specified under Section 3. The fiber that resulted from this procedure had a core of approximately 40 μm with an overall diameter of approximately 100 μm. Its length was 723 meters and optical attenuation was 2 dB/km at 1060–1100 nm.

EXAMPLE 2

A fused quartz tube 6 mm I.D. × 8 mm O.D. was cleaned as described and positioned in a glass lathe. Flows of diluted (1 percent by volume in N_2) silane, germane, diborane, and oxygen were passed through the tube as follows:

SiH_4: 1,000 cc/min.
GeH_4: 150 cc/min.
B_2H_6: 50 cc/min.

Deposition commenced by heating the tube locally using an oxyhydrogen flame which was traversed along the length of the tube. The complete cycle took 3.7 minutes, and the highest temperature attained was 1400

degrees C. After 175 minutes, the gas flows were stopped and the tube collapsed in one additional pass, made at a much slower rate. Temperatures achieved here were in the vicinity of 1750–1900 degrees C. The preform was removed to a pulling apparatus and drawn to a fiber whose diameter was 100microns overall. This consisted of a core whose composition was SiO_2-GeO_2-B_2O_3 of approximately 25 microns diameter. The cladding had the composition of SiO_2. The index difference produced by the core was 0.007.

EXAMPLE 3

A clean fused silica tube 6 mm I.D. ×8 mm O.D. was positioned in a glass lathe was previously described. Flows of diluted (3.05 percent by volume in N_2) silane, diborane, and oxygen were passed through the tube as follows:

SiH_4: 295 cc/min.
B_2H_6: 49 cc/min.
O_2: 900 cc/min.

Deposition commenced by heating the tube locally using an oxyhydrogen torch which traversed along the tube at a rate of 0.10 cm/sec as the tube rotated at 100–120 rpm. The torch was adjusted so as to produce a temperature locally of 1375–1450 degrees C. When the torch had moved to the end of the tube, it was returned at 0.15 cm/sec with the SiH_4 and B_2H_6 flows stopped. This procedure continued for three hours. At this time the B_2H_6 flow was stopped and just SiH_4 and O_2 continued. At the same time, the torch was adjusted to produce temperatures of 1600–1650 degrees C., other conditions remaining the same as previously. Depositing the pure SiO_2 layer continued for 1.5 hours.

At this time, silane flow was stopped and just O_2 flow continued at 600 cc/min. Temperatures were varied during the next two passes to 1650–1700 degrees C. Now the oxygen was stopped, the traverse slowed to 0.05 cm/sec, and the temperature raised to 1850–1890 degrees C. to bring about complete collapse of the tube.

This procedure produced a preform having a core of pure SiO_2, a cladding layer of B_2O_3-SiO_2, and an outer jacket of commercial grade SiO_2. The fiber drawn from this preform had a core of 30 μm, cladding thickness of 15 μm and an outer jacket of 20 μm, with an index difference of 0.007 percent and losses of 3 dB/km at 1.06 μm wavelength.

EXAMPLE 4

For optical communications employing multimode optical fibers it is desirable to more nearly equalize the group velocities of propagating modes. This result is expected if the index of the core is gradually increased from the cladding toward the interior of the core. To accomplish this an 8 mm I. D. ×10 mm O.D. fused quartz tube was positioned and borosilicate layer intended to serve as a portion of the cladding and as a barrier layer was deposited as in Example 1. Next deposition of the GeO_2-B_2O_3-SiO_2 core was commenced except that the germania content was gradually increased from zero during the period of deposition. The conditions used during the deposition were as follows:

Barrier layer
$SiCl_4$: 32 cc/min
BCl_3: 12.5 cc/min
O_2: 250 cc/min
Temp: 1740 degrees C.
Time: 25 min.

Graded Index portion of the core

$SiCl_4$: 33 cc/min
BCl_3:
12.5 7.5 cc/min
17 equal increments at
2 min intervals
$GeCl_4$:
0–35 cc/min
17 equal increments at
2 min intervals
O_2:
460–830 cc/min
17 equal increments at
2 min intervals
Temp: 1470 degrees C.

Constant Index portion of core
$SiCl_4$: 32 cc/min
BCl_3: 7.5 cc/min
$GeCl_4$: 35 cc/min
O_2: 830 cc/min
Temp: 1470 degrees C.
Time: 53 min.

At the conclusion of the deposition, the tube was collapsed to yield a solid preform which was then pulled to yield an optical fiber. When the mode dispersion of this fiber was measured, it behaved in a manner expected of a graded index. This behavior can be expressed by relation (Bell System Technical Journal 52, pp. 1566 (1973)) $\eta=\eta_0[1-2\Delta(r/a)^{\alpha}]^{\frac{1}{2}}$ where in this instance the value of $\alpha=5$.

What is claimed is:

1. A method of making an optical fiber preform suitable for drawing into an optical fiber including the steps of: providing a hollow glass tube of a first refractive index and having a predetermined length with a bore formed therethrough; introducing into said bore, in unreacted dry vapor form, material that forms a glass layer, coating said bore by thermally depositing said material thereon to form a glass layer of higher refractive index than the refractive index of said tube; rotating said glass tube about its longitudinal axis by a rotating device, while heating said coated tube to collapse said tube into a solid preform having substantially the same length as said predetermined length whereby the glass coating layer becomes a core of said higher index of refraction than the refractive index of said tube.

2. The method of making an optical fiber preform as set forth in claim 1, wherein said tube is made of a silica glass and wherein said material includes germania and silica in order to produce an optical fiber preform having a core of mixed germania-silica composition.

3. The method of claim 1 wherein the coating, rotating and heating steps occur in the order recited.

4. A process for fabrication of a glass optical fiber preform having a core section and a cladding comprising the steps of: introducing a moving stream of a vapor mixture including at least one compound glass forming precursor together with an oxidizing medium into a tube of a predetermined length, heating the tube and contents by a moving hot zone produced by a correspondingly moving heat source external to the tube so as to react the said mixture and produce a glassy layer on the inner surface of the tube, rotating said glass tube about its longitudinal axis by a rotating device, while heating said coated tube to collapse said tube into a solid preform having substantially the same length as said predetermined length whereby the glass coating layer becomes a core having a higher index of refraction than the refractive index of said tube.

5. The process of claim 4 wherein said vapor mixture includes oxygen and chlorides of silicon and germanium.

6. The process of claim 4 wherein the first mentioned heating, the rotating and the second mentioned heating steps occur in the order recited.

7. A method of making an optical fiber preform having a glass core and a glass cladding comprising the steps of: introducing a stream of vapors into the interior of a glass tube having a first refractive index and a predetermined length, said vapor being chemically reactive in the process of heating to form glass substantially similar to that of said glass core, establishing a localized hot zone in the interior of said glass tube to react vapor within said hot zone, moving said hot zone longitudinally along substantially the same length of said glass tube to coat a layer of glass substantially similar to said glass core on the inside wall of said glass tube, rotating said glass tube about its longitudinal axis by a rotating device, while heating said coated tube to collapse said tube into a solid preform having substantially the same length as said predetermined length whereby the glass coating layer becomes a core having a higher index of refraction than the refractive index of said tube.

8. The method of claim 7 wherein the moving, rotating and heating steps occur in the order recited.

9. A method of making an optical fiber preform suitable for drawing into an optical fiber including the steps of:

providing a hollow glass tube of a first refractive index and having a predetermined length with a bore formed therethrough;

introducing into said bore, in unreacted dry vapor form, material that forms a glass layer,

coating said bore by thermally depositing said material thereon to form a glass layer of higher refractive index than the refractive index of said tube;

rotating said coated glass tube about its longitudinal axis by a rotating device; and

heating said rotating coated tube to collapse said tube into a solid preform having substantially the same length as said predetermined length whereby the glass coating layer becomes a core of said higher index of refraction than the refractive index of said tube.

10. The method of claim 9 wherein said heating step is accomplished by passing a heat source along the length of said tube.

11. The method of claim 10 wherein said core includes germania and silica.

12. A process for fabrication of a glass optical fiber preform having a core section and a cladding comprising the steps of:

introducing a moving stream of a vapor mixture including at least one compound glass forming precursor together with an oxidizing medium into a tube of a predetermined length,

heating the tube and contents by a moving hot zone produced by a correspondingly moving heat source external to the tube so as to react the said mixture and produce a glassy layer on the inner surface of the tube,

rotating said coated glass tube about its longitudinal axis by a rotating device; and

heating said rotating coated tube to collapse said tube into a solid preform having substantially the same length as said predetermined length whereby the glass coating layer becomes a core having a higher index of refraction than the refractive index of said tube.

13. The process of claim 12 wherein the second-mentioned heating step is accomplished by passing a heat source along the length of said tube.

14. The process of claim 12 wherein said core includes germania and silica.

15. A method of making an optical fiber preform having a glass core and a glass cladding comprising the steps of:

introducing a stream of vapors into the interior of a glass tube having a first refractive index and a predetermined length, said vapor being chemically reactive in the process of heating to form glass substantially similar to that of said glass core,

establishing a localized hot zone in the interior of said glass tube to react vapor within said hot zone,

moving said hot zone longitudinally along substantially the same length of said glass tube to coat a layer of glass substantially similar to said glass core on the inside wall of said glass tube,

rotating said coated glass tube about its longitudinal axis by a rotating device; and

heating said rotating coated tube to collapse said tube into a solid preform having substantially the same length as said predetermined length whereby the glass coating layer becomes a core having a higher index of refraction than the refractive index of said tube.

16. The method of claim 15 wherein said heating step is accomplished by passing a heat source along the length of said tube.

17. The method of claim 15 wherein said core includes germania and silica.

* * * * *

United States District Court ★ Northern District of Georgia ★

EXHIBIT / ATTACHMENT

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(To be scanned in place of tab)

United States Patent [19]
Hart, Jr. et al.

[11] **Patent Number: 5,298,047**
[45] **Date of Patent: Mar. 29, 1994**

[54] **METHOD OF MAKING A FIBER HAVING LOW POLARIZATION MODE DISPERSION DUE TO A PERMANENT SPIN**

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[73] Assignee: **AT&T Bell Laboratories**, Murray Hill, N.J.

[21] Appl. No.: **924,278**

[22] Filed: **Aug. 3, 1992**

[51] Int. Cl.[5] C03B 37/025
[52] U.S. Cl. 65/3.11; 65/3.43; 65/34; 65/10.1; 264/1.5
[58] Field of Search 264/1.5; 65/3.11, 3.4, 65/3.43, 3.44, 3.2, 3.12, 10.1

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Primary Examiner—W. Gary Jones
Assistant Examiner—John Hoffmann
Attorney, Agent, or Firm—Eugen E. Pacher

[57] **ABSTRACT**

The presence of (typically unintended) birefringence in single mode optical fiber can severely limit the usefulness of the fiber for, e.g., high bit rate or analog optical fiber communication systems, due to the resulting polarization mode dispersion (PMD). It has now been discovered that PMD can be substantially reduced if, during drawing of the fiber, a torque is applied to the fiber such that a "spin" is impressed on the fiber. Desirably the torque is applied such that the spin impressed on the fiber does not have constant spatial frequency, e.g., has alternately clockwise and counterclockwise helicity. At least a portion of optical fiber according to the invention has a spin whose spatial frequency exceeds 4 spins/meter.

4 Claims, 3 Drawing Sheets

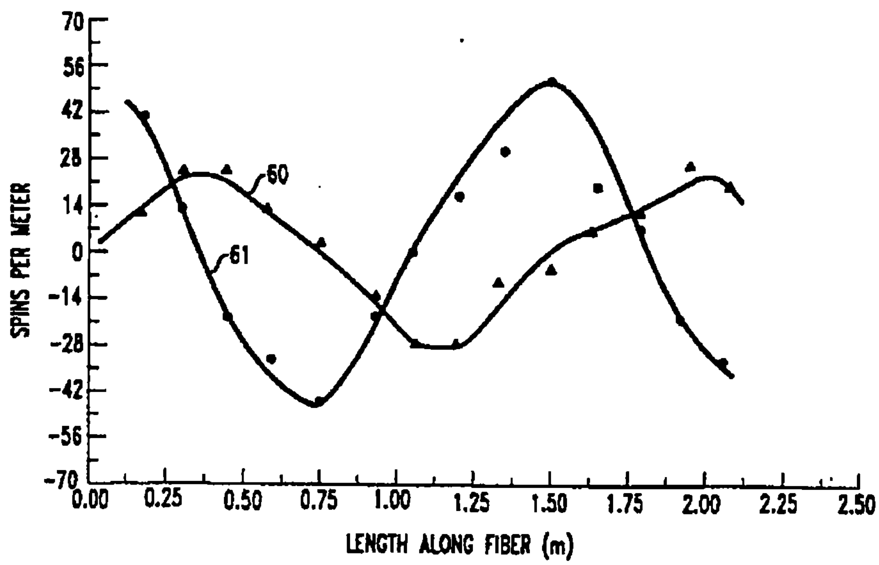


FIG. 1
(PRIOR ART)

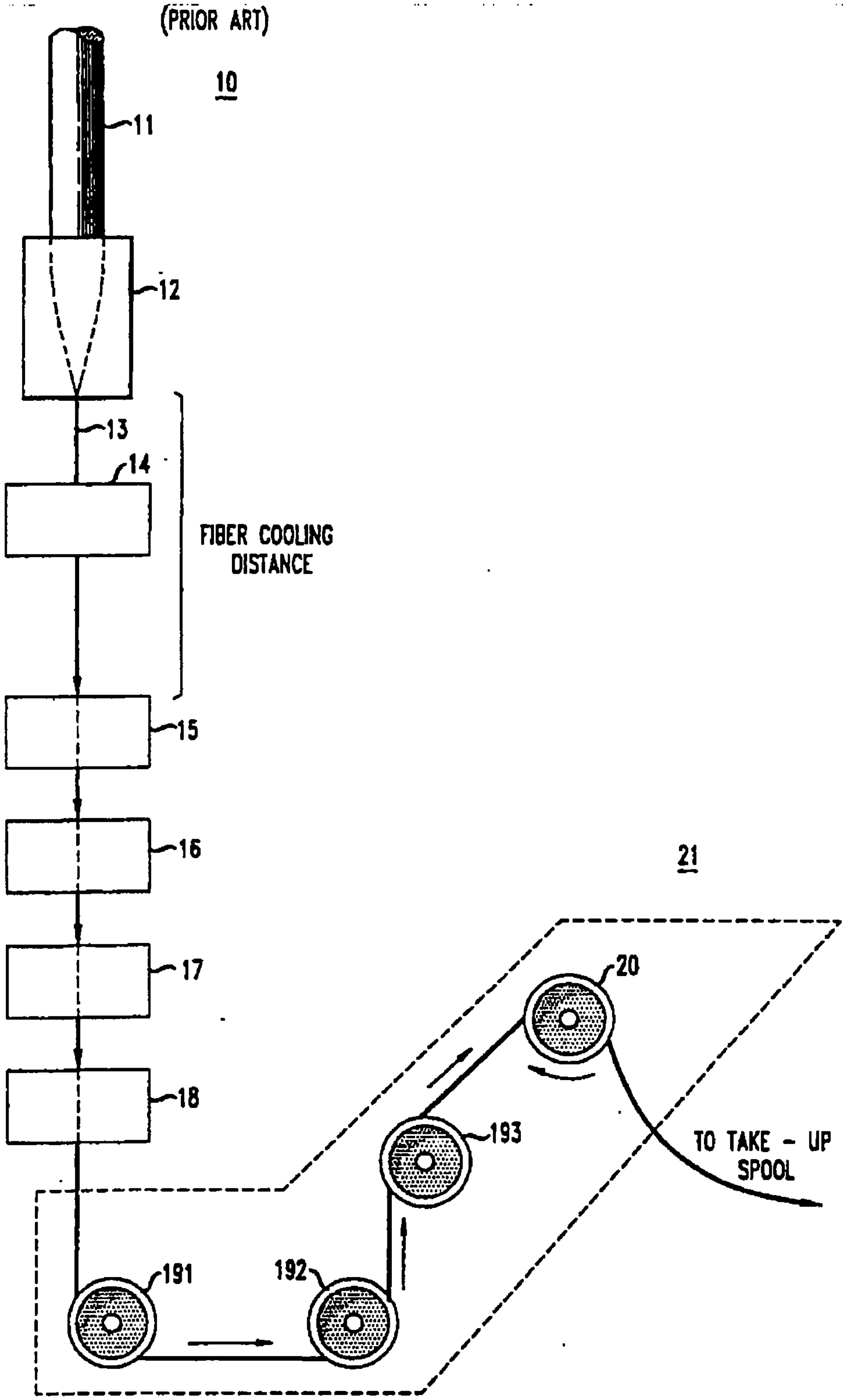


FIG. 2
(PRIOR ART)

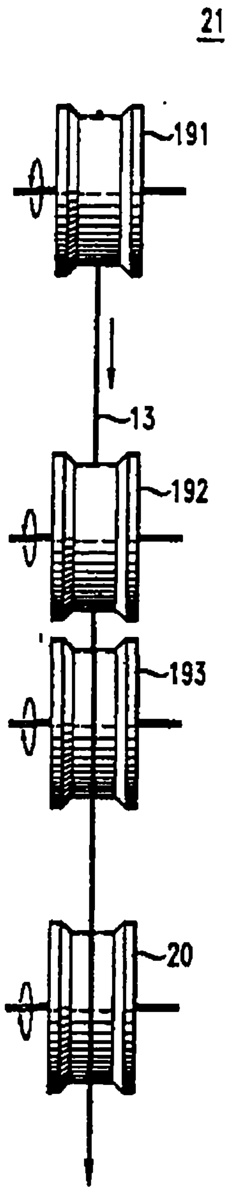


FIG. 3

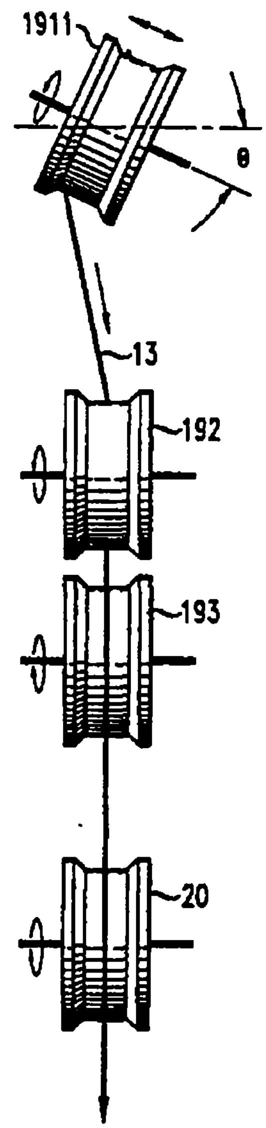


FIG. 4

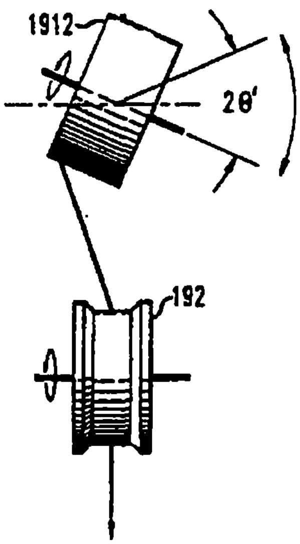


FIG. 5

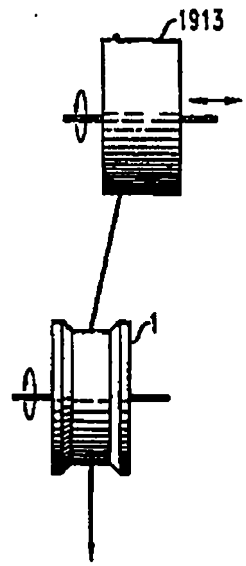
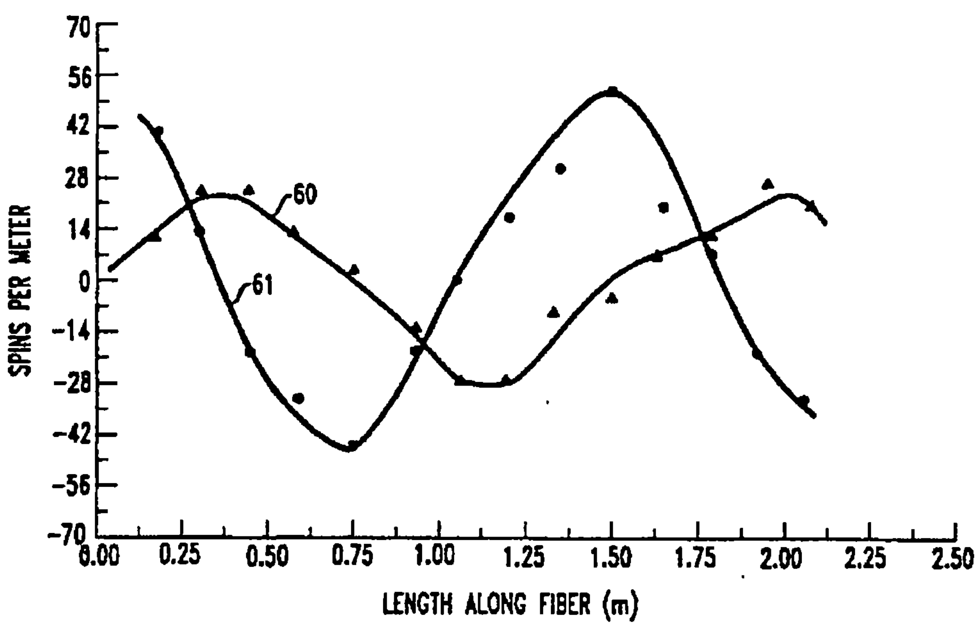


FIG. 6



METHOD OF MAKING A FIBER HAVING LOW POLARIZATION MODE DISPERSION DUE TO A PERMANENT SPIN

FIELD OF THE INVENTION

This invention pertains to optical fibers, in particular, to single mode optical fiber having relatively low polarization mode dispersion (PMD). It also pertains to communication systems that comprise such fiber, and to methods of making such fiber.

BACKGROUND OF THE INVENTION

An ideal circularly symmetric "single mode" optical fiber can support two independent, degenerate modes of orthogonal polarization. Either one of these constitutes the fundamental HE_{11} mode. In general, the electric field of light propagating along the fiber is a linear superposition of these two polarization eigenmodes.

In practical single mode fiber, various imperfections such as asymmetrical lateral stress and a non-circular core typically break the circular symmetry of the ideal fiber and lift the degeneracy of these two polarization modes. The two modes then propagate with different phase velocities, and this difference between their effective refractive indices is called birefringence.

Fiber birefringence can result from either a geometrical deformation or from various elasto-optic, magneto-optic or electro-optic index changes. In so-called polarization-preserving fibers asymmetry is deliberately introduced into the fiber. However, in ordinary (non-polarization-preserving) fibers the birefringence mechanisms act on the fiber in substantially unpredictable manner. Thus, the polarization state of the guided light will typically evolve through a pseudorandom sequence of states along the fiber, with the polarization state at the fiber output typically being both unpredictable and unstable. On average, a given polarization state in a given fiber is reproduced after a certain length L_p, the polarization "beat" length associated with the given fiber.

The presence of birefringence in conventional single mode fiber results in signal dispersion (so-called polarization mode dispersion or PMD) and thus typically is undesirable, especially for applications that involve high bit rates or analog transmission (e.g., for optical fiber analog CATV systems).

It is known that fiber having low PMD can be produced by rapidly spinning the preform while pulling the fiber from the preform. The prior art teaches that this results in periodically interchanged fast and slow birefringence axes along the fiber, which can lead to very low net birefringence due to piecemeal compensation of the relative phase delay between the polarization eigenmodes, provided the spin pitch is much less than the "un-spun" fiber beat length. See, for instance, A. Ashkin et al., *Applied Optics*, Vol. 20(13), p. 2299; A. J. Barlow et al., *Applied Optics*, Vol. 20(17), p. 2962; and S. C. Rashleigh, *Laser Focus*, May 1983.

It is primarily the prior art requirement that the spin pitch be much less than the "unspun" L_p which makes the prior art technique substantially unsuitable for current commercial fiber production. For instance, assuming that the unspun L_p is about 1 m and the draw speed is 10 m/seconds, then the preform has to be spun at 6000 rpm in order to yield a spin pitch that is 1/10th of the unspun L_p. This is typically not practical in commercial fiber production.

In view of the commercial significance of low birefringence optical fiber, it would be highly desirable to have available a technique for producing such fiber that is compatible with current commercial practice, e.g., that is usable even at the high draw speeds that are typically used now. This application discloses such a technique.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically depicts exemplary prior art fiber draw apparatus;

FIG. 2 shows, schematically and in top view, the guide portion of the apparatus of FIG. 1;

FIGS. 3-5 depict, also schematically and in top view, exemplary guide portions that can be used to practice the invention; and

FIG. 6 shows exemplary data on spin vs. distance along the fiber, for fiber according to the invention.

THE INVENTION

Broadly speaking, the invention is embodied in a novel and convenient method of making optical fiber, typically single mode fiber, that can be used to produce fiber having low PMD, exemplarily less than 0.5 $ps/km^{\frac{1}{2}}$. It is also embodied in a novel type of low PMD fiber, and in articles (e.g., an optical fiber communication system) that comprise such fiber.

More specifically, the inventive method comprises providing a conventional optical fiber preform, heating at least a portion of the preform to a conventional draw temperature, and drawing optical fiber from the heated preform in such a way that a spin is impressed on the fiber. Significantly, a torque is applied to the fiber such that the fiber is caused to twist around its longitudinal axis, with a resulting torsional deformation of the fiber material in the hot zone.

A spin is "impressed" on the fiber herein if fiber material in the hot zone is caused to be torsionally deformed, with the deformation being frozen into the fiber, such that the fiber exhibits a permanent "spin", i.e., a permanent torsional deformation. The existence of such a frozen-in spin can be readily ascertained, e.g., by microscopic examination of the fiber to determine rotation of core ovality or eccentricity, or by means of a traveling magneto-optic modulator, as used by M. J. Marrone et al., *Optics Letters*, Vol. 12(1), p. 60. Associated with such a frozen-in spin is a pitch, the spin repeat distance along the fiber.

As will be readily appreciated by those skilled in the art, the prior art method of spinning the preform results in a spin of essentially constant pitch. It is known that small twists of the symmetry axes can occur during the drawing process such that even conventional single-mode fibers exhibit a variation in the optical polarization along the fiber. See, for instance, the above cited Marrone et al. paper. However, we know of no case of prior art fiber with unintended spin whose spin had a spatial frequency in excess of 4 spins/meter. See, for instance, M. J. Marrone et al., op. cit., Table 1. Fiber having such low spin typically does not exhibit commercially significant reduction in PMD. Thus, fiber according to the invention comprises a portion or portions having spin spatial frequency in excess of 4 spins/meter, preferably in excess of 10 or even 20 spins/meter.

In currently preferred embodiments of the invention, the torque is applied intermittently to the fiber, whereby the spin impressed on the fiber has a pitch that is not constant over substantial lengths of fiber, e.g., is not constant over the beat length L_p. We currently believe that non-constant pitch can have advantages over constant pitch, since low pitch can also couple the two polarization modes, provided the pitch is precisely matched with the fiber birefringence spatial frequency. See, for instance, S. C. Rashleigh, J. of *Lightwave Technology*, Vol. LT-1(2), pp. 312–331, especially p. 320, where it is stated that, " . . . regardless of the actual distribution f(z) of the birefringence perturbations, only the one spectral component with frequency β_i can couple the two polarization eigenmodes. All other spectral components do not efficiently couple the modes". The parameter β_i is the intrinsic birefringence of the fiber, and $F(\beta_i)$ is the Fourier transform of f(z). Since the perturbation f(z) is essentially random, it is clear that a constant pitch spin will typically not result in efficient mode coupling. On the other hand, non-constant pitch spin, especially spin that has alternately positive and negative helicity, is likely to contain spatial components that produce efficient coupling. We currently believe that strong coupling can be obtained with spin of varying spatial frequency that comprises, in addition to regions of relatively high spin spatial frequency, regions of relatively low spin spatial frequency. This is, for instance, the case if the spin alternates between positive and negative helicity.

The invention is also embodied in optical fiber (exemplarily SiO_2-based fiber comprising a core and a cladding, with the former having larger effective refractive index than the cladding material that surrounds the core) that is produced by the inventive method. It is also embodied in an article (e.g., an optical fiber communication system that comprises a source of an optical signal, means for detecting an optical signal, and an optical fiber according to the invention signal-transmissively connecting the detector means and the source. More specifically, a spin is impressed on the fiber, with the spin not being constant along the fiber, and with at least a portion of the fiber having a spatial spin frequency in excess of 4 spins/meter.

FIG. 1 schematically depicts conventional (prior art) drawing apparatus 10. Fiber preform 11 is slowly fed (by means of a feed mechanism that is not shown) into furnace 12, where fiber 13 is drawn from the necked down portion of the preform. The bare fiber passes through diameter monitor 14 into coating applicator 15, wherein the polymer coating (frequently comprising an inner and an outer coating) is applied to the, by now relatively cool, bare fiber. After passing through coating concentricity monitor 16 the fiber passes through curing station 17. Exemplarily 17 comprises UV lamps. Downstream from 17 is coating diameter monitor 18, followed by guide means (e.g., rollers 191, 192, 193) and drive means (e.g., pulling capstan 20) in region 21. It will be noted that guide roller 191 is the first contact point of the fiber with a solid. At this point the fiber is already protected by a cured polymer coating. It will also be noted that the draw force is provided by capstan 20, and that the rotational speed of 20 determines the draw speed, which exemplarily can be as high as 20 m/second. From 20 the fiber typically is lead to (independently driven) take-up means, e.g., a take-up spool. Those skilled in the art will recognize that FIG. 1 shows several optional features (e.g., 14, 16, 18), and does not show all possible features (e.g., a hermetic coating chamber between 12 and 15). However, FIG. 1 exemplifies currently used conventional drawing apparatus.

In the prior art apparatus of FIG. 1 the fiber essentially moves in a single plane at least between its point of origin in the furnace and the capstan, and no twist is intentionally impressed on the fiber. See FIG. 2, which is a schematic top view of portion 21 of the apparatus of FIG. 1.

According to the invention, a torque is applied to the fiber such that a spin is impressed on the fiber. Although in principle the torque could be applied at any downstream point (prior to take-up) at which the fiber has cooled sufficiently to be contacted, it is generally not desirable to contact the bare fiber. Thus, the torque advantageously is applied at a point downstream from curing station 17, typically at an appropriate point in region 21. It is currently most preferred to apply the torque by means of the first guide roller.

We have discovered that an intermittent torque can be applied to the fiber, such that a twist with non-constant pitch is impressed on the fiber. This can, for instance, be accomplished by changing the orientation of guide roller 1911 of FIG. 3, exemplarily by canting the roller by an angle θ around a direction parallel to the draw tower axis. Canting roller 1911 as indicated causes the fiber to oscillate back and forth on the roller, in response to lateral forces that automatically arise in this arrangement. More specifically, the lateral forces translate into a torque on the fiber, which causes the fiber to roll laterally on roller 1911, thereby moving the fiber out of the plane defined by the fiber in the prior art (un-canted) apparatus. It will be appreciated that the lateral roll is superimposed on the conventional draw motion. The lateral motion of the fiber is believed to give rise to a restoring force that increases with increasing lateral displacement of the fiber, causing the fiber to jump back (substantially, but not necessarily exactly) into the plane, only to immediately begin another sidewise roll. This non-symmetrical back-and-forth motion is indicated by the double-headed arrow adjacent to roller 1911 in FIG. 3. The angular rotation speed of the fiber during the lateral roll is, inter alia, a function of the cant angle θ. Thus, the pitch of the spin impressed on the fiber is also a function of θ. For instance, particular draw apparatus used by us yielded average pitches of 14 and 7 cm for $\theta=7°$ and 15°, respectively. It will be appreciated that these values are exemplary only, since the pitch will depend, inter alia, on the configuration and height of the draw tower, the draw speed, the draw tension and the coating viscosity.

Those skilled in the art will recognize that the described exemplary method not only impresses a spin on the fiber but also introduces a substantially equal and opposite (generally elastic) twist into the taken-up fiber. Although such fiber may be acceptable for some purposes (e.g., for sensor purposes that require only a relatively short length of fiber), it will generally be desirable to remove (or prevent the introduction of) the unwanted elastic twist. The elastic twist can, for instance, be removed by appropriate respooling. However, it is preferable to substantially prevent introduction of the elastic twist. This can be accomplished by alternately imposing a clockwise and a counterclockwise torque on the fiber, exemplarily as described below.

Causing the guide roller 1912 of FIG. 4 to oscillate about an axis that is parallel to the fiber draw direction

(which is typically the same as the draw tower axis) alternately impresses positive and negative spin on the fiber. Furthermore, the resulting positive and negative elastic twists on the fiber substantially cancel, such that the fiber on the take-up spool is substantially free of torsional elastic strain. Guide roller 1912 of FIG. 4 can be caused to oscillate back and forth by any appropriate means, e.g., by eccentric drive means (not shown). An alternate arrangement is schematically shown in FIG. 5, wherein guide roller 1913 is caused to move back and forth axially, by appropriate conventional means that are not shown, resulting in alternate application of clockwise and counterclockwise torque on the fiber.

Those skilled in the art will recognize that the guide and drive means 21 of FIG. 1 can take many forms. For instance, sheaves (as shown in FIGS. 1-3) may be used, or ungrooved rollers may be used, or sheaves and ungrooved rollers may be used in combination (exemplarily as shown in FIGS. 4 and 5). All appropriate guide and drive means are contemplated, as are all appropriate means for applying an appropriate torque to the fiber.

FIG. 6 shows exemplary experimental data, namely, the spin spatial frequency (in spins/m) as a function of distance along the fiber. Curve 60 was obtained from a single mode fiber which was drawn at 1.5 m/second, with 60 cycles/minute of the oscillating guide roller 1912 of FIG. 4), and curve 61 from an otherwise identical single mode fiber which was drawn at 3 m/second, with 106 cycles/minute of roller 1912. As can be seen from FIG. 6, each of the fibers contains portions whose spin spatial frequency is far in excess of 4 spins/m (even in excess of 20 spins/m), and in each of the fibers the spin is non-constant, even having clockwise and counterclockwise helicity, resulting in substantial likelihood that the spin comprises a component that is effective in coupling the two polarization modes.

Those skilled in the art will appreciate that the pitch of the spin impressed on fiber drawn in apparatus of the type shown in FIG. 4 depends, inter alia, on the oscillation amplitude $2\theta'$ and the oscillation frequency. For instance, in a particular fiber draw apparatus according to the invention θ' was about 15°, and the oscillation frequency was about 106 cycles/minute. These values are exemplary only, and those skilled in the art will, aided by the teachings herein, be able to not only adapt their draw apparatus to practice the invention but also to select draw parameters that are suitable for their particular apparatus.

We claim:

1. A method of making an optical fiber comprising
a) providing an optical fiber preform;
b) heating at least a portion of said preform; and
c) drawing optical fiber from the heated preform such that a spin is impressed on the fiber; wherein
d) step c) comprises, while maintaining the preform rotationally stationary, applying a torque to the fiber, said torque causing the fiber to undergo rotation around the longitudinal axis of the fiber such that the spin is impressed on the fiber as it is drawn from the preform, wherein the torque is applied such that the spin impressed on the fiber does not have a constant spatial frequency.

2. Method according to claim 1, wherein the torque is alternately applied in clockwise and counterclockwise direction, such that the spin impressed on the fiber is alternately clockwise and counterclockwise.

3. Method according to claim 2, wherein step c) comprises coating the fiber with a polymer coating and causing the coated fiber to contact a guide roller, wherein the alternating torque is applied by means of said guide roller.

4. Method according to claim 3, wherein applying the torque by means of the guide roller comprises causing the guide roller to oscillate about an axis that is substantially parallel to a fiber draw direction.

* * * * *

CERTIFICATE OF SERVICE

I certify that on this 26th day of February, 2004, a true and correct copy of the foregoing **FOURTH AMENDED COMPLAINT** was served upon counsel for Sterlite Optical Technologies, Inc.; Sterlite Optical Technologies, Limited; Anand Agarwal; and Brian Chomniak by the manner indicated, addressed as follows:

Sumner Rosenberg (Hand Delivery)
Lawrence K. Nodine
Bernard L. Zidar
NEEDLE & ROSENBERG PC
999 Peachtree Street, Suite 1000
Atlanta, Georgia 30309

ORIGINAL

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF GEORGIA
ATLANTA DIVISION

FILED IN CLERK'S OFFICE

MAR 11

FURUKAWA ELECTRIC NORTH AMERICA, INC.

Plaintiff,

v.

STERLITE OPTICAL TECHNOLOGIES, INC.; STERLITE OPTICAL TECHNOLOGIES, LIMITED; ANAND AGARWAL; and BRIAN CHOMNIAK.

Defendants.

Civil Action No.
1:02-CV-2149-CAP

ANSWER AND COUNTERCLAIM OF DEFENDANTS STERLITE OPTICAL TECHNOLOGIES, INC.; STERLITE OPTICAL TECHNOLOGIES, LIMITED; ANAND AGARWAL; AND BRIAN CHOMNIAK TO PLAINTIFF FURUKAWA ELECRIC NORTH AMERICA, INC.'S FOURTH AMENDED COMPLAINT

Defendants Sterlite Optical Technologies, Inc.; Sterlite Optical Technologies, Limited; Anand Agarwal; and Brian Chomniak (collectively "Defendants"), by and through their attorneys, answer Plaintiff's Fourth Amended Complaint as follows:

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DEFENDANTS' ANSWER AND AFFIRMATIVE DEFENSES

First Affirmative Defense

The United States Patent No. 4,909,816, and each claim thereof, is invalid for failing to comply with the requirements of the patent laws of the United States, specifically 35 U.S.C. §§ 101, 102, 103 and 112, and the judicially-created obviousness-type double patenting.

Second Affirmative Defense

The United States Patent No. 5,298,047, and each claim thereof, is invalid for failing to comply with the requirements of the patent laws of the United States, specifically 35 U.S.C. §§ 101, 102, 103, and 112.

Third Affirmative Defense

The United States Patent No. 5,418,881, and each claim thereof, is invalid for failing to comply with the requirements of the patent laws of the United States, specifically 35 U.S.C. §§ 101, 102, 103, and 112.

By way of further answer, Defendants respond to the individually numbered paragraphs of the Fourth Amended Complaint as follows:

The Parties

1. Defendants are without knowledge or information sufficient to form a belief as to the truth of the allegations in Paragraph 1 of the Fourth Amended Complaint.

2. Admitted.

3. Sterlite U.S. does not sell optical fiber in this judicial district. All other allegations in this paragraph are admitted.

4. Denied.

5. Denied.

6. Admitted that the quoted text appeared on the Internet website www. sterliteoptical.com as of November 3, 2003. All other allegations of this paragraph are denied.

7. Admitted that Anand Agarwal is a citizen of India. Admitted that Anand Agarwal is an officer of Sterlite India and Sterlite U.S. All other allegations of this paragraph are denied.

8. Admitted that Brian Chomniak resides in Duluth, Georgia at 8730 Innisbrook Run. Admitted that Brian Chomniak is employed by Sterlite Optical

Technologies, Inc. as Vice President of Operations. All other allegations of this paragraph are denied.

Jurisdiction and Venue

9. Admitted that Plaintiff alleges patent infringement and trade secret misappropriation in the Fourth Amended Complaint. Subject Matter Jurisdiction is admitted. Venue is admitted. Personal Jurisdiction over Sterlite Optical Technologies Ltd. is admitted. All other allegations of this paragraph are denied.

The Patents in Suit

10. Defendants admit that U.S. Patent No. 4,909,816 ("the '816 patent") bears an issue date of March 20, 1990 and that Exhibit A attached to the Fourth Amended Complaint is a true and correct copy of the '816 patent. Defendants deny the remaining allegations in Paragraph 10 of the Fourth Amended Complaint.

11. Defendants admit that U.S. Patent No. 5,298,047 ("the '047 patent") bears an issue date of March 29, 1994 and that Exhibit B attached to the Fourth Amended Complaint is a true and correct copy of the '047 patent. Defendants deny the remaining allegations in Paragraph 11 of the Fourth Amended Complaint.

12. Defendants admit that U.S. Patent No. 5,418,881 ("the '881 patent") bears an issue date of May 23, 1995 and that Exhibit C attached to the Fourth

Amended Complaint is a true and correct copy of the '881 patent. Defendants deny the remaining allegations in Paragraph 12 of the Fourth Amended Complaint.

13. Defendants are without knowledge or information sufficient to form a belief as to the truth of the allegations in Paragraph 13 of the Fourth Amended Complaint.

14. Defendants admit that the '816 patent contains method claims for making an optical fiber preform. Defendants deny the remaining allegations in Paragraph 14 of the Fourth Amended Complaint.

15. Defendants admit that the '047 patent contains claims directed generally to a method of making optical fibers. Defendants admit that the '881 patent contains claims directed generally to optical fibers and an optical communication system including an optical fiber. Defendants admit that the presence of birefringence in an optical fiber can limit the usefulness of the fiber due to signal dispersion and that this phenomenon is known as polarization mode dispersion ("PMD"). Defendants deny the remaining allegations in Paragraph 15 of the Fourth Amended Complaint.

16. Defendants admit that the '816, '047 and '881 patents were all issued by the United States Patent and Trademark Office. Defendants deny that the purported inventions claimed within the '816, '047 and '881 patents are patentable

or that these patents were legally or properly issued. Defendants are without knowledge or information sufficient to form a belief as to the truth of the remaining allegations in Paragraph 16 of the Fourth Amended Complaint.

17. Denied.

18. Denied.

Count 1 – Direct Infringement of the '816 Patent

19. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

20. Denied.

21. Denied.

22. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 22 of the Fourth Amended Complaint.

23. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 23 of the Fourth Amended Complaint.

Count 2 – Direct Infringement of the '047 Patent

24. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

25. Denied.

26. Denied.

27. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 27 of the Fourth Amended Complaint.

28. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 28 of the Fourth Amended Complaint.

Count 3 – Direct Infringement of the '881 Patent

29. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

30. Denied.

31. Denied.

32. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 32 of the Fourth Amended Complaint.

33. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 33 of the Fourth Amended Complaint.

Count 4 – Inducing Infringement of the '881 Patent

34. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

35. Denied.

36. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 36 of the Fourth Amended Complaint.

37. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 37 of the Fourth Amended Complaint.

Count 5 – Contributory Infringement of the '881 Patent

38. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

39. Denied.

40. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 40 of the Fourth Amended Complaint.

41. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 41 of the Fourth Amended Complaint.

Count 6 – Inducing Infringement of the '816 Patent (Alternative)

42. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

43. Denied.

44. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 44 of the Fourth Amended Complaint.

45. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 45 of the Fourth Amended Complaint.

Count 7 – Inducing Infringement of the '047 Patent (Alternative)

46. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

47. Denied.

48. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 48 of the Fourth Amended Complaint.

49. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 49 of the Fourth Amended Complaint.

Count 8 – Inducing Infringement of the '881 Patent (Alternative)

50. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 18 of the Fourth Amended Complaint.

51. Denied.

52. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 52 of the Fourth Amended Complaint.

53. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 53 of the Fourth Amended Complaint.

Count 9 - Willful Infringement

54. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 53 of the Fourth Amended Complaint.

55. Denied.

56. Denied.

57. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 57 of the Fourth Amended Complaint.

58. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 58 of the Fourth Amended Complaint.

59. Denied.

Count 10 – Misappropriation of Trade Secrets

60. Defendants incorporate by reference and reallege the responses and denials set forth in their answers to Paragraphs 1 through 9 of the Fourth Amended Complaint.

61. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 61 of the Fourth Amended Complaint.

62. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 62 of the Fourth Amended Complaint.

63. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 63 of the Fourth Amended Complaint.

64. Admitted.

65. Admitted that a meeting occurred in September, 1999 between representatives of Sterlite Optical Technologies, Ltd. and Lucent. All other allegations of this paragraph are denied.

66. Denied.

67. Admitted that the parties did not enter a license agreement. All other allegations of this paragraph are denied.

68. Denied.

69. Denied.

70. Denied.

71. Denied.

72. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 72 of the Fourth Amended Complaint.

73. Denied.

74. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 74 of the Fourth Amended Complaint.

75. Defendants are without knowledge or information sufficient to form a belief as to the allegations in Paragraph 75 of the Fourth Amended Complaint.

Jury Demand

76. Paragraph 65 contains no factual allegations requiring admission or denial.

COUNTERCLAIMS

For its counterclaims against Furukawa, Defendants Sterlite Optical Technologies, Inc., Sterlite Optical Technologies, Ltd., Anand Agarwal and Brian Chomniak ("Defendants") allege as follows:

77. Sterlite India is a company organized under the laws of India having its registered office at E-1, Waluj M.I.D.C. Industrial Area, Waluj, District Aurangabad 431136, Maharashtra India.

78. Upon information and belief, Furukawa Electric North America, Inc. is a Delaware Corporation with its principal place of business at 2000 Northeast Expressway, Norcross, Georgia 30071.

79. Defendants counterclaims seek declaratory judgments of invalidity of U.S. Patent No. 4,909,816, U.S. Patent No. 5,298,047 and U.S. Patent No. 5,418,881, arising under the Declaratory Judgment Act, 28 U.S.C. § 2201 *et seq.* and the Patent Laws of the United States, including 35 U.S.C. § 1 *et seq*.

80. Furukawa is subject to the personal jurisdiction of this Court.

81. This Court has subject matter jurisdiction over this action pursuant to 28 U.S.C. §§ 1331, 1338, 2201 and 2202.

82. Venue exists in this district under 28 U.S.C. §§ 1391(b) and (c).

Count I - Declaratory Judgment of Invalidity of U.S. Patent No. 4,909,816

83. Defendants incorporate and reallege paragraphs 77-82 above as if each allegation in those paragraphs were set forth fully herein.

84. Furukawa, by its Fourth Amended Complaint, alleges it is the owner through assignment of all right, title and interest in the '816 patent.

85. The '816 patent and each claim thereof is invalid.

86. An actual justiciable controversy exists between the parties as to the validity of the '816 patent.

87. Defendants are entitled to judgment by this Court declaring the '816 patent invalid.

Count II - Declaratory Judgment of Invalidity of U.S. Patent No. 5,298,047

88. Defendants incorporate and reallege paragraphs 77-82 above as if each allegation in those paragraphs were set forth fully herein.

89. Furukawa, by its Fourth Amended Complaint, alleges it is the owner through assignment of all right, title and interest in the '047 patent.

90. The '047 patent and each claim thereof is invalid.

91. An actual justiciable controversy exists between the parties as to the validity of the '047 patent.

92. Defendants are entitled to judgment by this Court declaring the '047 patent invalid.

Count III - Declaratory Judgment of Invalidity of U.S. Patent No. 5,418,881

93. Defendants incorporate and reallege paragraphs 77-82 above as if each allegation in those paragraphs were set forth fully herein.

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94. Furukawa, by its Fourth Amended Complaint, alleges it is the owner through assignment of all right, title and interest in the '881 patent.

95. The '881 patent and each claim thereof is invalid.

96. An actual justiciable controversy exists between the parties as to the validity of the '881 patent.

97. Defendants are entitled to judgment by this Court declaring the '881 patent invalid.

Claims for Relief

WHEREFORE, Defendants request that:

1. The Court declare that the '816 patent, and each claim thereof, is invalid;

2. The Court declare that the '047 patent, and each claim thereof, is invalid;

3. The Court declare that the '881 patent, and each claim thereof, is invalid;

4. The Court grant Defendants such other and further relief as may be deemed appropriate and just.

Respectfully submitted, this 11th day of March, 2004.

SUMNER C. ROSENBERG
Georgia Bar No. 614550
LAWRENCE K. NODINE
Georgia Bar No. 545250
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Counsel for Defendants
Sterlite Optical Technologies, Inc.;
Sterlite Optical Technologies, Limited;
Anand Agarwal; and Brian Chomniak.

**IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF GEORGIA
ATLANTA DIVISION**

FURUKAWA ELECTRIC NORTH AMERICA, INC. Plaintiff, v. STERLITE OPTICAL TECHNOLOGIES, INC.; STERLITE OPTICAL TECHNOLOGIES, LIMITED; ANAND AGARWAL; and BRIAN CHOMNIAK. Defendants.	Civil Action No. 1:02-CV-2149-CAP

CERTIFICATE OF SERVICE

This certifies that I have this day served a true and correct copy of the within and foregoing **ANSWER AND COUNTERCLAIM OF DEFENDANTS STERLITE OPTICAL TECHNOLOGIES, INC.; STERLITE OPTICAL TECHNOLOGIES, LIMITED; ANAND AGARWAL; AND BRIAN CHOMNIAK TO PLAINTIFF FURUKAWA ELECRIC NORTH AMERICA, INC.'S FOURTH AMENDED COMPLAINT** upon all counsel of record in the manner indicated below:

☐ By Hand ☐ By Facsimile ☒ By US Postal Service (1st Class) ☐ By Overnight Delivery ☐ By Email	H. Stephen Harris, Jr. Keith E. Broyles Dana Marty Haas Alston & Bird LLP 1201 West Peachtree Street Atlanta, GA 30309
☐ By Hand ☐ By Facsimile ☒ By US Postal Service (1st Class) ☐ By Overnight Delivery ☐ By Email	John P. Higgins Michael D. McCoy Alston & Bird LLP 101 South Tryon Street, Suite 4000 Charlotte, NC 28280-4000

This 11th day of March, 2004.

Bernard L. Zidar

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF GEORGIA
ATLANTA DIVISION

FURUKAWA ELECTRIC NORTH AMERICA, INC.,

Plaintiff,

v.

STERLITE OPTICAL TECHNOLOGIES, LIMITED; STERLITE OPTICAL TECHNOLOGIES, INC.; ANAND AGARWAL; and BRIAN CHOMNIAK,

Defendants.

CIVIL ACTION

NO. 1:02-CV-2149

O R D E R

This matter is before the court on the following motions: (1) the plaintiff's motion to compel discovery responses [Doc. No. 70], (2) the plaintiff's motion for an extension of time to respond to discovery [Doc. No. 68], (3) the plaintiff's motion for a protective order [Doc. No. 69], and (4) the plaintiff's motion to extend the discovery deadline and for a scheduling conference [Doc. No. 71].

Procedural History

The plaintiff designs, manufactures and supplies optical fiber, optical fiber cable, optical connectivity products, and speciality photonics products for high speed optical networks. On August 8, 2002, Fitel USA Corp. ("Fitel"), filed the instant patent infringement action against Fibercore, Inc. ("Fibercore") to defend

its interest in three patents related to optical fibers (the "Furukawa Patents").

On November 14, 2002, Fitel amended its complaint to add defendant Sterlite Optical Technologies, Inc. ("Sterlite US") as a party defendant. Sterlite US imported optical fiber made by Sterlite Optical Technologies, Limited ("Sterlite India") into the United States and then packaged the optical fiber into optical fiber cable for sale within the United States. Approximately one month after Sterlite US was added as a party defendant, the court dismissed defendant Fibercore for lack of personal jurisdiction.

On December 13, 2003, after discovery was almost complete, Fitel filed a motion for leave to file a Third Amended Complaint adding a claim for trade secret misappropriation. The motion also sought leave to add Sterlite India, Mr. Anand Agarwal, and Mr. Brian Chomniak as party defendants. As grounds for this motion, Fitel claimed that it sought to pierce the corporate veil of Sterlite US and hold Sterlite India responsible for the damages caused by Sterlite US's infringement of the Furukawa Patents and misappropriation of Fitel's trade secrets, and for inducing Sterlite US to infringe the Furukawa Patents. Specifically, Fitel alleged that Sterlite India controlled Sterlite US and is the company that developed and manufactured optical fiber and optical fiber cables for Sterlite US. Fitel also claimed that Mr. Agarwal, who was an officer of both Sterlite India and Sterlite US, and Mr.

Chomniak, who was an officer of Sterlite US, aided and abetted in the misappropriation of Fitel's trade secrets.

The court, with the consent of Sterlite US, granted Fitel's motion for leave to amend on January 27, 2004, and ordered Fitel to file its Third Amended Complaint. Instead of filing its Third Amended Complaint, on February 26, 2004, the plaintiff filed a Fourth Amended Complaint, which was substantially similar to the Third Amended Complaint except that it noted that Fitel had changed its name to Furukawa Electric North America, Inc. (the "plaintiff"). The defendants consented to the filing of the Fourth Amended Complaint.

A few months after the plaintiff filed its Fourth Amended Complaint, the court held a status conference addressing the timing of any additional discovery necessitated by the plaintiff's Fourth Amended Complaint. On May 19, 2004, the court endorsed the parties' Supplemental Joint Preliminary Report and Discovery Schedule ("Discovery Schedule") extending fact discovery until January 15, 2005. Because the parties agreed to attend mediation, the Discovery Schedule ordered the parties to attend a mediation conference no later than July 18, 2004. Prior to attending mediation, however, the defendants were excused from responding to any outstanding discovery requests.

Despite the court's endorsement of the Discovery Schedule, the parties did not attend mediation in July. Instead, the plaintiff

moved the court to extend the deadline for the parties to participate in a mediation conference until September 24, 2004, on the ground that defense counsel was going to seek leave to withdraw. The motion for leave to withdraw was filed with the court on July 30, 2004, and was granted on September 14, 2004. The court also granted the plaintiff's motion for leave to extend the date of mediation until September 24, 2004.

Despite the court's order allowing the parties until September 24, 2004, to complete mediation, the parties did not do so, in part, because the defendants' new counsel did not enter an appearance until September 29, 2004. After defense counsel entered their appearance, the parties did attempt to set a date for mediation, but were unable to agree upon an acceptable date for mediation.

Pursuant to the Discovery Schedule, fact discovery closed on January 15, 2005. Because the Discovery Schedule excused the defendants from responding to outstanding discovery requests until after mediation and the parties could not agree on an acceptable mediation date, little to no discovery was completed during the time period from the court's endorsement of the Discovery Schedule to the close of fact discovery. This scheduling crunch precipitated the instant motions. A status conference and hearing ("Status Conference") regarding these motions was held on Monday, April 18, 2005.

Legal Analysis

1. The Fourth Amended Complaint

As noted above, on February 26, 2004, without first seeking leave of the court, the plaintiff filed its Fourth Amended Complaint [Doc. No. 53]. The Fourth Amended Complaint made minor changes to the Third Amended Complaint and noted that the plaintiff had changed its name from Fitel USA Corp. to Furukawa Electric North America, Inc.

At the Status Conference, the defendants indicated that they consented to the filing of the Fourth Amended Complaint. As such, the court grants the plaintiff leave to file the Fourth Amended Complaint and accepts the Fourth Amended Complaint, which was filed on February 26, 2004 [Doc. No. 53]. The case will proceed under the Fourth Amended Complaint.

2. The plaintiff's motion to compel discovery responses, the plaintiff's motion for an extension of time to respond to discovery, and the plaintiff's motion for a protective order

At the Status Conference, the plaintiff indicated that these motions are moot. See Pl.'s Reply in Supp. of its Discovery Mots. at 3 n.2 [Doc. No. 91]. As such, the plaintiff's motion to compel discovery responses [Doc. No. 70], the plaintiff's motion for an extension of time to respond to discovery [Doc. No. 68], and the plaintiff's motion for a protective order [Doc. No. 69] are DISMISSED as moot.

3. The plaintiff's motion to extend the discovery deadline and for a scheduling conference

Because attending a mediation conference was a condition precedent to the defendants responding to discovery, and because the withdrawal of defense counsel caused a delay in setting a date for mediation, the plaintiff filed a motion asking the court to extend fact discovery until June 1, 2005. The defendants objected to this extension of time and requested a much more limited extension of the discovery period - until March 31, 2005. The defendants also asked that fact discovery during that time be severely circumscribed such that the parties could only respond to outstanding discovery requests and could not serve new discovery requests.

Because the Status Conference could not be arranged until April 18, 2005, several weeks after the new date proposed by the defendants for the close of discovery, the court ordered the parties to submit a proposed amended Joint Preliminary Report and Discovery Plan prior to the Status Conference. Accordingly, the parties submitted their Proposed Amended Joint Preliminary Report and Discovery Plan [Doc. No. 96] on Friday, April 15, 2005. The deadlines proposed in the Proposed Amended Joint Preliminary Report and Discovery Plan differ from those proposed by either party in their original motion and objections. As a result, the plaintiff's motion to extend the discovery deadline is DISMISSED as moot to the

extent it requests an extension of the discovery deadline until June 1, 2005.

The court has reviewed the Proposed Amended Joint Preliminary Report and Discovery Plan [Doc. No. 96] and ADOPTS it subject to the following changes:

a. At the Status Conference, the defendants expressly abandoned their claim that Nextrom (USA) should be joined as a party defendant. [See Doc. No. 96 at 7].

b. The defendants will produce in Atlanta all relevant, non-privileged documents requested by the plaintiff that were generated in whole or in part by the following former employees of Sterlite US: (1) Paul Bendig; (2) Jim Burnett; (3) Rusty Yother; (4) David Ernest; (5) Michael Johnson; and (6) Brian Chomniak. The defendants shall produce all remaining relevant, non-privileged documents requested by the plaintiff and generated by either Sterlite US or Sterlite India in India.

c. Depositions of the defendants' employees who are currently working in India shall take place in India.

d. Pursuant to the Patent Local Rules, this case will follow the schedule attached to this order as Exhibit A.

Conclusion

For the foregoing reasons, the court hereby:

(1) GRANTS the plaintiff leave to file its Fourth Amended Complaint and accepts the Fourth Amended Complaint, which was filed on February 26, 2004 [Doc. No. 53];

(2) DISMISSES as moot the plaintiff's motion to compel discovery responses [Doc. No. 70];

(2) DISMISSES as moot the plaintiff's motion for an extension of time to respond to discovery [Doc. No. 68];

(3) DISMISSES as moot the plaintiff's motion for a protective order [Doc. No. 69];

(4) GRANTS IN PART and DISMISSES IN PART as moot the plaintiff's motion to extend the discovery deadlines and for a scheduling conference [Doc. No. 71]; the motion is granted to the extent that the plaintiff requested a scheduling conference, which was held on April 18, 2005; the motion is dismissed as moot to the extent that the plaintiff moved to extend the discovery deadline until June 1, 2005; discovery will be governed by the schedule attached as Exhibit A to this order; and

(5) ADOPTS the proposed amended joint preliminary report and discovery plan [Doc. No. 96] subject to the changes previously set forth in this order.

SO ORDERED, this 19th day of April, 2005.

CHARLES A. PANNELL, JR.
United States District Judge

Exhibit A

Event	**Date**
Pursuant to LPR 4.1, the plaintiff s serve its Disclosure of Infringement Contentions upon the defendants.	May 9, 2005
The defendants shall file with the court any objections to the sufficiency of the plaintiff's Disclosure of Infringement Contentions. A courtesy copy of the objections must be hand-delivered to the court.	May 13, 2005
The plaintiff shall file its response to the defendant's objections to the sufficiency of the plaintiff's Disclosure of Infringement Contentions. A courtesy copy of the response must be hand-delivered to the court.	May 18, 2005
Pursuant to LPR 4.2-4.3, the defendant shall serve their Response to the plaintiff's Infringement Contentions and their Disclosure of Invalidity Contentions.	June 1, 2005
The plaintiff shall file with the court any objections to the sufficiency of the defendant's Invalidity Contentions. A courtesy copy of the objections must be hand-delivered to the court.	June 7, 2005
The defendants shall file their response to the plaintiff's objections to the sufficiency of their Disclosure of Invalidity Contentions. A courtesy copy of the response must be hand-delivered to the court.	June 13, 2005
Pursuant to LPR 6.1, the parties shall simultaneously exchange a list of claim terms, phrases or clauses which the party contends should be construed by the court and identify any claim element, which the party contends should be governed by 35 U.S.C. § 112(6).	June 14, 2005

Pursuant to LPR 6.2, the parties shall simultaneously exchange a preliminary proposed construction of each claim term, phrase or clause, which any party has identified for claim construction.	July 1, 2005
Pursuant to LPR 6.3, the parties shall file a Joint Claim Construction Statement.	July 22, 2005
Pursuant to LPR 6.4, discovery relating to claim construction shall close.	August 1, 2005
Pursuant to LPR 6.5(a), each party shall file and serve its opening brief and evidence supporting its claim construction.	August 12, 2005
Pursuant to LPR 6.5(b), each party shall file and serve its responsive brief and supporting evidence regarding claim construction.	September 1, 2004
Markman hearing	To be determined by the court
The fact discovery period shall close. Prior to this date, the parties are free to pursue all fact discovery available under the Federal Rules of Civil Procedure, except that discovery regarding claim construction will close on August 1, 2005.	The date the court issues its Markman Order + 45 days
Pursuant to LPR 7.1 (b), for issues other than claim construction, each party shall make its expert witness disclosures on the issues for which it bears the burden of proof.	Close of fact discovery + 30 days
Pursuant to LPR 7.1(c), for the issues other than claim construction, each party shall make its initial expert witness disclosures on the issues for which the opposing party bears the burden of proof.	Close of fact discovery + 60 days
Pursuant to LPR 7.1(d), each party shall make its rebuttal expert witness disclosures.	Close of fact discovery + 70 days

Pursuant to LPR 7.2, the deposition period for expert witnesses shall commence.	Close of fact discovery + 77 days.
Pursuant to LPR 7.2, the depositions period for expert witnesses shall close.	Close of fact discovery + 107 days.
Deadline for dispositive motions	Close of fact discovery + 137 days
Pursuant to LPR 5.2, discovery on the substance of the opinions of counsel shall commence.	Earlier of: (1) five days after a ruling on summary judgment indicating a triable issue of fact to which willfulness would be relevant; or (2) 30 days prior to the close of fact discovery